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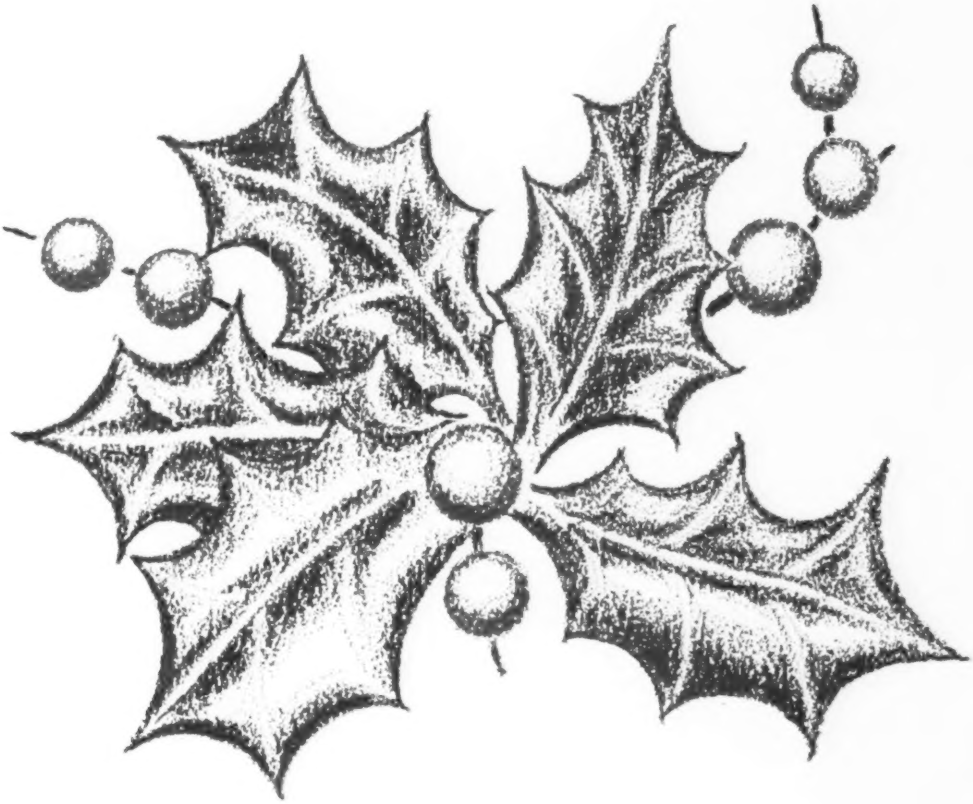
THE SCIENCE TEACHER



JOURNAL OF THE NATIONAL SCIENCE TEACHERS ASSOCIATION

THE SCIENCE TEACHER

Articles published in THE SCIENCE TEACHER are the expressions of the writers. They do not represent the policy of the Association or the Magazine Advisory Board.

The National Science Teachers Association is a department of the National Education Association and an affiliate of the American Association for the Advancement of Science. Established in 1895 as the NEA Department of Science Instruction and later expanded as the American Council of Science Teachers, it merged with the American Science Teachers Association and reorganized in 1944 to form the present Association.

Vol. XXV, No. 8 December 1958

Editor's Column

Charles F. Kettering—never another like him, and never to be replaced but a man always to be remembered. Dead at 82 on November 25, "Boss Ket" has won a permanent place in the history of American invention and industrial research; also in my opinion in American folklore of interest and of use to the science teacher.

Mr. Kettering produced countless unique phrases expressing a philosophy of teaching and learning which seems worthy of frequent reference. His admonitions were mostly overdrawn; nevertheless they carried real punch when told in his blunt, homespun fashion.

"Education is all wrong; you fail once and you're out. In research and invention, you succeed once and you're in."

"Research is simply an attitude of mind . . . To me, science is merely finding out how nature does things . . . It's just as simple as that."

Two of "Boss Ket's" researches which were carried on with the collaboration of Dr. Thomas P. Midgley will remain as classics of "the scientific method" in action—one, the successful research for a nontoxic, nonflammable, noncorrosive refrigerant; the other a quest for an engine antiknock, which resulted in the discovery of tetraethyl lead.

His burning curiosity about answers to baffling scientific questions—"Why is grass green?" "Why can we see through glass?" and others—led to his support, for example, of the Sloan-Kettering Institute for Cancer Research and of photosynthesis research at Antioch College, Yellow Springs, Ohio.

I am proud to have as my home town the same one which Mr. Kettering adopted as his own—Dayton, Ohio—and where he did practically all of his work prior to about 1925. I knew personally one of the men who made original drawings of the automobile self-starter, done in the basement of a neighborhood home "after work" and far into the night. Some thirty years ago I heard my first of half a dozen talks given by "Boss Ket"—one in which he told about calling in his staff and telling them that he wanted an automobile painted in much less than 37 days. Some time later they reported they had the time down to two weeks. He exploded and said: "I want it done in one hour." The upshot of this was the first *Duco,* a paint that dried so fast it dropped as dry powder before hitting the automobile. Then the problem was to slow down the drying time!

Mr. Kettering's most direct activity in pre-college science teaching was through his presidency of the Thomas Alva Edison Foundation and its series of Institutes on science teaching, which NSTA helped inaugurate in 1951; and the ninth meeting which was held in Cincinnati, Ohio with "Ket" an active participant, less than two weeks before his death. A man who lived 82 years, who invented, innovated, discovered, and gave us leadership as Mr. Kettering did would not ask for tears and laments on his passing. He has left a great deal to enrich the teaching of science which is ours to use.

Robert H. Carleton

THE SCIENCE TEACHER

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*** Includes the *Elementary School Science Bulletin* and *Tomorrow's Scientists*.**

Readers' Column

My grateful thanks to you and your colleagues for the invaluable help they have given me, and the free material they have sent me since I became a member of NSTA.

Many of your books are finding their way in my library by degree.

Sister Mary Charles, O.P.
Dominican College
Belfast, Ireland

I am a ninth grader in Dennis Junior High School here in Richmond. My father is a science and biology teacher at Brownsville, and is a member of NSTA.

You send out wonderful papers and articles to teachers. I try to read all that Daddy receives. I certainly enjoy them.

Patricia H. Williams
Richmond, Indiana

I am glad to see the new service on publications being offered in HECTOR'S CORNER of the Science Teacher magazine.

Stanley Holzhauer
Science Dept.
Bloomington High School
Bloomington, Illinois

Your office is making very fine contributions to better science teaching. I count my membership a blessing. *ST* and the many other publications your office puts out are most helpful in planning my materials and demonstrations.

Brother Raymund, F.S.C.
St. Mary's High School
Waltham 54, Massachusetts

As a member of NSTA I would like to see the inductive method publicized among our active teachers as I feel that in it lies a great challenge to our better chemistry teachers of today. I am submitting an article. Having found many stimulating articles in *TST* I would like to contribute my share too!

Sister Ernestine Marie
Saint Patrick's Convent
850 De Salaberry Avenue
Quebec 6, P.Q.

Your publication has been of great service to me during this first year of teaching. Thank you for the concise reports.

Loretta Schulz
405 High Street
Chestertown, Md.

The Association is absolutely the finest! The magazine, *The Science Teacher*, is everything one could want to stimulate one's own efforts and to make one conscious of what others are doing. I wouldn't miss it for the world!

Sr. M. Irenaea Winkeljohn
Regina High School
Norwood, Ohio

NSTA CALENDAR

As a regular feature of *The Science Teacher*, the calendar will list meetings or events of interest to science teachers which are national or regional in scope. Send your dates to *TST*'s calendar editor. Space limits listings of state and local meetings.

December 27-30, 1958: NSTA Annual Winter Meeting with science teaching societies affiliated with the American Association for the Advancement of Science, Washington, D. C.

December 28-30, 1958: 18th Christmas meeting of the National Council of Teachers of Mathematics, New York City

February 19-21, 1959: National Association for Research in Science Teaching, Atlantic City, New Jersey

February 21, 1959: Council for Elementary Science International (CESI), Atlantic City, New Jersey

February 28-March 1, 1959: CESI, Cincinnati, Ohio

April 3-4, 1959: CESI, St. Louis, Missouri

March 31-April 3, 1959: Annual Convention, National Catholic Educational Association, Atlantic City, New Jersey

March 31-April 4, 1959: NSTA Seventh National Convention, Atlantic City, New Jersey

WHAT ABOUT SCIENCE IS IMPORTANT TO TEACH?

By WALLACE W. SAWYER

Science Department Chairman, Weston, Massachusetts, Public Schools

WHEN PROPERLY TAUGHT and organized, science has much to contribute to the educational development of the entire population of our elementary and secondary schools. At an early age boys and girls show great curiosity regarding their physical and living environment. Teachers in the elementary grades, although little prepared in science, find that children are keenly interested in their surroundings and that science experiences are among the most fruitful in guiding the children to write, read, spell, and orally express themselves. This curiosity and eagerness continues on through the higher grades as demonstrated by the great variety of "how" and "why" questions asked by the children and their willingness to collect materials, create models, experiment, dissect, and investigate objects of their environment. In many of our elementary classrooms we find science being taught in a manner that is real and alive with meaningful activity and with children greatly enjoying these experiences.

Such an atmosphere does not as frequently prevail in the science classrooms of the junior and senior high school. As a rule teachers of these grades are more adequately prepared in science, but even so, the emphasis and method of presentation is quite different and the interest of boys and girls for science much lessened. The learning situation lacks challenge, interest, and opportunity to carry out real experiments that arise out of the "how" and "why" questions of the children. Learning of facts becomes the primary objective and reasoning and critical thinking are secondary. This leads to an atmosphere of boredom which can soon be detected as one visits the classroom. This situation of course does not prevail in all high schools, but it is much too common and is thought by some authorities to be one of the primary reasons as to why so many of our boys and girls of high school age are uninterested in science and scientific careers. During the high school years the pupils are very impressionable and their feelings and opinions toward science taught in the high school is predicated upon liking for science in later life. Can it be that the science taught in the high school is predicated upon a different philosophy as to the meaning of science? The author of this article is inclined to agree that such is the case. Certainly before attempting to answer the question contained in the title of this article it is necessary to agree as to what science really means.

Since the time of Galileo and Bacon much progress has been made in gaining an understanding of our physical and living environment. This immense amount of information has, over the years, been organized and arranged according to system. From this systematic and efficient classification of knowledge has come our various branches of science. Many science teachers, especially in high school and college, regard science as solely this body of classified factual information. With this as a definition, the objective in teaching science is to present factual information in as logical and systematic a manner as possible. Teaching is largely authoritative and boys and girls are expected to memorize and recite back what is said by the instructor and stated within the textbook. Although many pupils appear to achieve mastery through this method of teaching there is actually gained little real understanding and retention is very short. The learning situation is usually boring and generally uninspiring to the majority of the class.

Other science educators regard science as a great deal more than this knowledge we have gained. To these teachers, science is the method by which we have acquired this understanding. It is the rationale by which scientists today are learning new concepts and by which future scientific progress will be made. The dynamic aspect of this meaning of science has been well stated by Dr. James B. Conant[1] in his book *On Understanding Science:*

> "Science emerges from the other progressive activities of man to the extent that new concepts arise from experiments and observations, and the new concepts in turn lead to further experiments and observations."

This is an operational definition—science is as

[1] J. B. Conant. *Understanding Science*. New American Library of World Literature, New York. 1952.

scientists do. In simple terms it is how science goes about its business. With this meaning of science the objectives in teaching become quite different. Factual information although important is subordinate to how science functions.

In the use of historical materials, students gain understanding and appreciation of and interest in science. Based upon this latter philosophy of science a few cardinal principles of the scientific method appear to be fundamental to the teaching of all science. These I believe become the answer to "What About Science is Important to Teach?"

The Assumption of Order

In the book *The Common Sense of Science* by Bronowski[2] it is stated:

> "To this was added in the sixteenth and seventeenth centuries new assumption about the kind of order which science sets out to find or make. Roughly, the assumption amounts to this, that science is to get rid of angels, blue fairies with red noses, and other agents whose intervention would reduce the explanation of physical events to other than physical terms. The world is regular; the world is a machine."

This is the implicit belief of scientists that the events of nature are causally connected. It is the assumption that none of the events of nature occur arbitrarily, but rather are determined by various prior causes. That two or more isolated, similar systems started from the same conditions will run through the same course of events.

Experimentation and Observation

To science and scientists is often ascribed the task of explaining *why* things happen; actually, science is almost exclusively engaged in describing *how* things happen. In the days of Aristotle the emphasis was always on the *why* of nature. Scientists of this era developed a system of bold ideas arrived at by mixing logic with mathematics. These ideas were used to explain natural phenomena. They made little or no use of observation or experimentation in testing the correctness of their thinking. It was not until the sixteenth century when Galileo kept harping on *how* things happened that experimental science was founded. Galileo was forever concerned with a body of hard and irreducible facts and their correlation into laws prescribing behavior.

To one concerned with how things happen under certain conditions the next step is obvious; simulate the desired conditions, perform the test, and observe closely the results. The Law of Cause and Effect provides that if the conditions under which the experiment is performed do not vary, then the result of the experiment will also not vary. In other words experiments are reproducible, which means that the original experimenter or any other experimenter exactly imitating the original conditions of the test will obtain the same results when the test is performed. Cause is linked with effect. If the cause is modified, then the result is also altered. The effect is a function of the cause, useful information might be yielded if a *single* one of the conditions of a given experiment were systematically varied and the corresponding results obtained were closely observed. It is this process of systematic and controlled exploration that constitutes the major work of the world's scientific laboratories.

There is of course a basic difference between controlled experimentation and observation, and the two are present in mixed proportions in various sciences. Astronomy is an excellent example of a purely observational science since the motions or positions of the stars, planets, and other heavenly bodies cannot be manipulated by man to facilitate his search for knowledge. Physics, on the other hand, is a science which can be almost purely experimental. Between the two extremes range the other sciences.

The idea of accurate measurement is an essential part of the foundation of experimental science. Before Galileo the objective of the scientist was to classify knowledge. In experimental science the objective is to measure. The great progress of the physical sciences principally results from this concentration with measuring things carefully. A satisfactory answer of "how" things happen demands a quantitative statement of the relations involved. The chemical balance placed in the hands of men like Black, Priestley, and Lavoisier made possible the research that disproved the phlogiston theory. Examples of this sort are most numerous over the past three centuries.

From the intelligent appraisal of the data obtained from the progress of experiment and observation, the scientist may proceed to the

Induction of General Laws

Francis Bacon is recorded as the father of inductive reasoning. By definition, induction is a process of inference by reasoning from particulars to generals. Its application in science is illustrated by the formation of general laws of behavior from the consistent trends and relations made evident from experimental data. Examples of the results of induction are numerous in the various sciences. Most

[2] J. Bronowski. *The Common Sense of Science*. Harvard University Press, Cambridge, Massachusetts. 1953.

of our mathematical formulas predicting the behavior of natural phenomena are the result of careful experimentation. A typical example of this is shown in the labors of Robert Boyle of the seventeenth century who invented and used the air pump and vacuum apparatus in precise and quantitative experiments on the atmosphere and other gases. The data obtained lead through a process of induction to the generalization familiar to every school boy physicist as Boyle's Law: $PV=k$.

In recent times are experiments conducted by A. A. Michelson and E. W. Morley to determine the changes in the velocity of light relative to the earth caused by motion of the earth through the mysterious and subtile medium "ether." The results indicated no change at all in the speed of light relative to the earth, regardless of the relations between the directions of motion of earth and light. These results provided the data from which Albert Einstein developed his Theory of Relativity. These facts revealed by the experiments of Michelson and Morley were explained by the theory of Einstein. As shown above the induction of generalizations leads to the

Development of a Theory

Dr. James B. Conant,[3] in *Science and Common Sense,* has stated:

> "Almost all significant work of scientists today . . . comes under the heading of attempts to reduce the degree of empiricism . . . or to extend the range of theory."

In other words, the purpose of science is to increase man's ability of predicting behavior and controlling it without returning to the inefficient methods of trial and error. Science attempts to reduce numerous experimental facts and laws to a minimum of what Dr. Conant aptly calls "conceptual schemes." These schemes are of great value and importance to the scientist because they not only give a logical explanation of the facts observed, but also suggest new ideas for further experimentation and the acquisition of new facts. Indeed, it is by just this faculty of prediction that a theory falls or stands the test of time.

An example to illustrate the manner of a theory's growth and its effectiveness in gaining a more complete understanding of the nature of gases is the work of Robert Boyle. In explaining the data obtained in his experiments on gases he proposed that gases were made up of molecules in motion. This was the beginning of the Kinetic Molecular Theory. This explanation directed the experimentation of Charles, Gay-Lussac, Graham, and others greatly adding to our understanding of gaseous matter.

The above discussion on the growth and development of a theory reveals two further distinct steps in the scientific method. They are deductions from the theory, and further experimentation and observation. These have been well summarized in the book cited by J. Bronowski.

Documentation and Dissemination

Progress in science can only be brought about by experts working together and in full communication with one another, without regard to barriers of language and distance. The nature of this scientific communication imposes conditions of accuracy and honesty. Scientists do not have time to repeat the experiments of another. They must be accepted without verification. The scientist, as a consequence, expects and demands reports of the utmost accuracy and completeness. Great responsibility rests on scientists of rank sufficient for their findings to be published. Their writings can have great influence on the work of other scientists. For this reason the reputation of authors is involved, for their writings may be scrutinized most critically by fellow workers. It is this network of communication for scientific ideas, combined with the fruitfulness of theories in stimulating new experimentation, which causes our understanding of natural phenomena ever to increase.

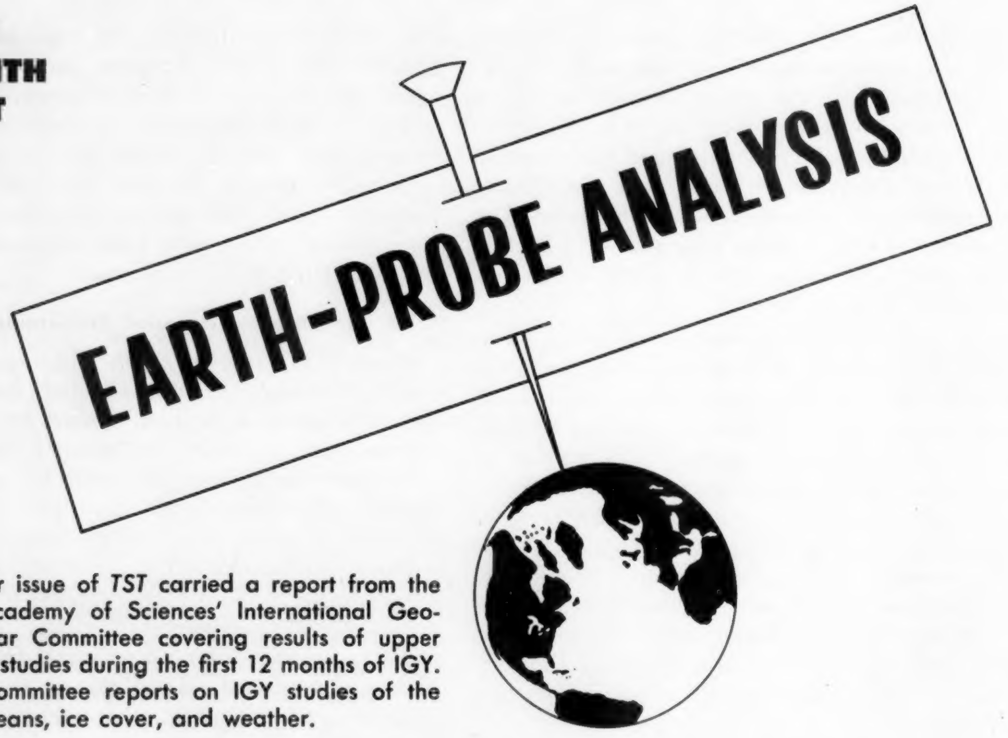
Conclusion

The purpose of this article is to answer the question, *What About Science is Important to Teach?* As previously stated it is the author's opinion that the fundamental objective of any science course is to develop within the minds of students a broad understanding of how science functions. Reduced to simplest terms this is the scientific method. The cardinal principles discussed above are not thought of as being in any fixed order, nor do they prevent anyone from starting his scientific investigation at any level of this method. When based upon this objective it becomes of vital importance that the science offering be organized and centered around the curiosity of boys and girls. The "how" and "why" questions raised become the real problems upon which the members of the class apply the previously described concepts of scientific investigation. The learning situation is exciting and with most students a high degree of interest prevails. Factual information will also be acquired and in a manner which gives true understanding and long retention.

[3] J. B. Conant. *op. cit.*

AN IGY 12-MONTH REPORT

EARTH-PROBE ANALYSIS



The October issue of *TST* carried a report from the National Academy of Sciences' International Geophysical Year Committee covering results of upper atmosphere studies during the first 12 months of IGY. Here the Committee reports on IGY studies of the earth, its oceans, ice cover, and weather.

IGY STUDIES have heavily underscored interrelationships among the earth sciences. Investigators in oceanography, glaciology, and meteorology find their studies must take each other's findings into account; the IGY disciplines of gravity, seismology, and longitude-latitude also must be integrated in any truly comprehensive examination of our earth.

Oceanography

One of the most important objectives of IGY oceanographic work is to learn more about how the deep waters of the oceans circulate. This information is significant in reaching a better understanding of the effect of the oceans on climate, the more efficient utilization of the oceans as a source of food—perhaps even their safe use for the deposit of atomic wastes.

Plumbing the Atlantic, IGY scientists already have discovered that far beneath the surface current known to all of us as the Gulf Stream flows a counter-current. This river in the sea moves in the opposite direction from the Gulf Stream. Some 9000 feet below the surface, it travels southwest at the rate of eight miles a day.

Another great counter-current, discovered three years ago, has been measured during an IGY cruise in the Pacific. Called the Cromwell Current after its discoverer, this huge stream moves about 1000 times as much water as the Mississippi River. It flows west to east for 3500 miles, running below and in the opposite direction from the Pacific Equatorial Current.

Water samples taken from the Atlantic by researchers of Woods Hole Oceanographic Institution have yielded the first adequate information concerning the distribution of organic and inorganic phosphorus in the sea. It has led them to believe that productivity in the open sea may be twice as great as previously estimated, a fact of importance in a world of increasing population.

Exploration of the oceans during IGY has resulted in discovery of great new underwater mountain ranges. Since the oceans cover more than 70 per cent of the earth's surface, and only 2 per cent of the ocean bottom has been sounded, it is not surprising that these ranges have been unknown up to now. One found in the southeast Pacific is 1000 miles long and 200 miles wide. Another extensive ridge was located under the Arctic ice by US-IGY scientists on a drifting icefloe, using gravity readings and seismic soundings.

What may be the sharpest rise in height on earth was found during an IGY oceanographic cruise. A depth of 25,000 feet was discovered off the coast of South America, less than 100 miles from the top of the Andes mountains which tower 23,000 feet above sea level. The total difference, from the floor of the ocean trench to the Andes peaks, is about twice the height of Mt. Everest.

Glaciology

Closely related to the study of the oceans is the study of glaciology. In polar and other areas, some of the water evaporated from the oceans falls as snow and is compressed into ice by later layers of snow. Eventually, glacial ice may flow back into the oceans, affecting their temperature and circulation.

The US-IGY glaciological program is the most comprehensive coordinated approach to the study of glaciers ever put into effect by scientists of this country. It includes observations in the Arctic—on floating ice islands in the Polar Sea, in Greenland, and in Alaska; in temperate areas such as the western United States; and on the great Antarctic ice sheet.

These studies have helped to enlarge our knowledge of the world's ice-covered areas, and in fact have revealed that the world's largest—Antartica—contains nearly twice as much ice as had been suspected. In one place, ice thickness of over 14,000 feet was detected by seismic soundings.

The IGY effort in Antarctica has perforce been a combination of exploration and observation. To understand many of the natural phenomena of the continent, it was necessary to investigate the basic geography of its uncharted interior. Traverse parties covered more than 4000 miles discovering new mountain ranges, fresh water lakes containing abundant plant life, penguin tracks far from any known shore line, and a deep, sub-glacial trough which must be followed further to determine whether Antarctica is indeed one continent, or is separated into two or more islands.

Glaciological work at fixed IGY stations in the Antarctic has included such pioneering activities as the recovery of intact ice cores from depths of more than 1000 feet. Successful completion of this delicate operation makes possible the development of weather information covering periods centuries before men kept such records, for the ice layers at the bottom of the drill holes were deposited perhaps 2000 years ago. Their character and content yield clues to climate variations, wind circulation, and related phenomena.

Solar radiation measurements during IGY have established that the Antarctic, although it is the sunniest place in the world during its midsummer, reflects up to 95 per cent of the sunlight it receives.

Study of the ice at the opposite end of the world is of both scientific and immediate practical interest. An apparent continuing shrinkage of the ice could open the Arctic Ocean to navigation before the end of the century. Yet at IGY Drifting Station A, during the last summer season, while 12 inches of ice on the upper surface of the floe melted, 18 to 24 inches of new ice accumulated on its bottom.

The IGY project at McCall Glacier in Alaska is the first direct scientific study of an Arctic alpine glacier. With supplies dropped by air, camps have been established at 6000 and 8200-foot elevations. One finding is that all significant snow accumulation occurs during the summer months.

Meteorology

The IGY meteorological program has been producing results from pole to pole, but perhaps most significantly in the Arctic and Antarctic, where great gaps existed in knowledge of weather.

Comparison of IGY observations at Little America with those made in the area almost 50 years earlier by Amundsen show that temperatures in the Antarctic have warmed up about 5° F. Similar observations in the Spitzbergen area indicate that Arctic temperatures have warmed up twice this amount. The possible effect of these warming trends on the icecaps is one of the tie-ins between meteorology and glaciology.

A great variety of weather data was collected by the 11 nations operating IGY stations in Antarctica. This was analyzed by the meteorologists of several nations who cooperated in the work of the IGY Weather Central at Little America. A first product is a description of Antarctic circulation, compiled jointly by a Russian and an Argentine at Little America, and published by the U.S. National Academy of Sciences. This type of information will be used in transpolar flights between the continents of the southern hemisphere,

Kainan Bay, Antarctica snow cave, formed by wind and movement of ice is data source on the stratigraphy and petrofabrics of ice and snow.

NATIONAL ACADEMY OF SCIENCES—IGY

in studies of the effect of the Antarctic on world weather, and in gaining better understanding of the fundamental mechanisms which produce or change weather conditions.

Certain chemical properties of the Antarctic atmosphere, studied for the first time as a result of the IGY program, have led to a more complete picture of atmospheric circulation in general. Carbon dioxide, for example, was found in the Antarctic in the same quantities as in rural areas of the United States. Products of nuclear fission in the Northern Hemisphere have been detected in the Southern Hemisphere. Ozone was found in the Antarctic in greater quantities during the sunless winter than in the daylight months, even though it is believed to be created by solar ultraviolet radiation. All these factors point to a high degree of mixing in the atmosphere, and to atmospheric circulation between Northern and Southern Hemispheres, rather than independent systems as once believed.

As part of an IGY pole-to-pole chain of stations along the 80th meridian west, five upper-air sounding stations were established through cooperation of the US Weather Bureau with the meteorological services of Chile, Ecuador, and Peru. In addition to providing valuable research information on such matters as transport of heat, momentum, energy and water vapor, the data from these stations have proved of great practical importance in airline operations. One US airline operating in South America states that the network paid for itself in a single day, when it supplied information on a severe Argentine storm, enabling the company to take extraordinary precautions.

Seismology

Seismological work was undertaken during the IGY by 52 nations at 325 locations. U.S. programs in this field ranged from Thule to the South Pole, from the Indian Ocean to the Andes.

The first seismographic records of earthquake waves ever obtained in Antarctica now are being analyzed. The results will either confirm or modify records from the Pacific, on the borders of which the majority of earthquakes occur. They also will yield information on the structure of the Antarctic region itself at depths too great for manmade seismic explosions to be useful.

In the Andes, a special type of seismic instrument developed at the California Institute of Technology is being used under the IGY program. These "extensometers" measure three things: the accumulation of long-range strains; daily earth tidal movements; and ultra-long period seismic waves, including possible free vibrations of the earth excited by earthquakes.

OFFICIAL US NAVY PHOTO

Dr. Herfried Hoinkes of Austria, IGY meteorologist at Little America Station, examines rotating cup anemometers used to determine wind velocity.

The long-range strain data, if accumulated over a sufficient period of time, might reveal enough about the strain pattern of a region to provide an ultimate basis for the prediction of earthquakes.

The measurements of the tidal strain produced each day in the earth by the gravitational action of the sun and the moon provide information on the elastic and plastic properties of the earth's outer crust, while the long-period waves yield information concerning the mantle and core of the earth and mechanism of earthquake generation.

A curious characteristic of earth tides—the lack, in certain places, of synchronization with water tides—is being checked on a round-the-world basis during IGY, as a possible clue to rigidity beneath the oceans and beneath the continents. Sensitive gravity meters have revealed, for example, that the two tides are in phase in Austin, Texas, but four hours apart on the West Coast.

As part of the IGY seismic studies of continental structure, an expedition to the Andes recorded the waves sent through the mountains by blasts in the copper mines of Chile and Peru on the other side of the range. The scientists sought to test the theory that mountains float in the earth's crust much as icebergs do in the sea; in other words, that great peaks above indicate a large mass below.

They found, however, that larger peaks were not over thicker crust, and that waves even from 50-ton explosions could not be recorded on the other side of the mountains. They concluded that the mountains might be supported by a fine network of roots going deep into the earth's crust or even into its mantle and serving to absorb the explosion waves.

(Continued on page 464)

AO Reports on Teaching with the Microscope

An old box camera, some cardboard and model airplane cement . . . or do-it-yourself photomicrography.

Without question the microscope and the camera have a certain natural affinity for one another. Everyone, it seems, who has ever looked through a microscope and used a camera has had the desire to apply the one to the other and photograph the invisible detail revealed to his eye.

American Optical profits in a small way from this affinity, manufacturing a truly excellent photomicrographic camera at a most reasonable price. Your request for the $300.00 plus required for one of these precise research instruments would get short shrift, however, from your school administrators. So, without fear of losing business, we can proceed to outline our little plan for a very rudimentary, do-it-yourself photomicrographic camera set-up that would be entirely adequate for preliminary student excursions into the art of photomicrography.

TAKE ANY OLD BOX CAMERA

Our photomicrographic set-up will consist of an ordinary box camera for holding the film and a cardboard box arrangement for focusing. Any old clunker of a box camera will do . . . just make sure it has a setting for time exposure.

CONSTRUCTING ADAPTERS:

Construct two cardboard adapters, one inch high out of stiff cardboard (1/16" approx.) and model airplane cement (see fig. 1). Holes should be cut to fit snugly over microscope eyepiece.

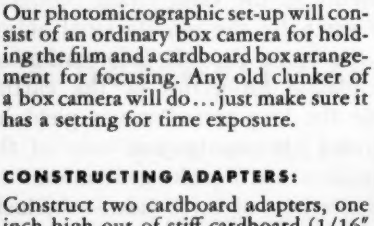


FIG. 1

PROCEDURE FOR ADAPTING CAMERA:

Remove lens from camera, (reflecting surfaces of the camera lens will produce glare, or "hot spots" on film). Tape one adapter to camera, (see fig. 1). Load camera with standard panchromatic roll film.

PROCEDURE FOR CONSTRUCTING FOCUSING DEVICE:

Construct eight inch high cardboard viewer by cementing three sides around second adapter (see fig. 2). After three sides are cemented, mount ground glass (ground side down) to cardboard shelf and then cement on fourth side.

NOTE: Ground glass *must be* same distance from face of adapter on viewer as film plane of camera is from face of its adapter (see fig. 2).

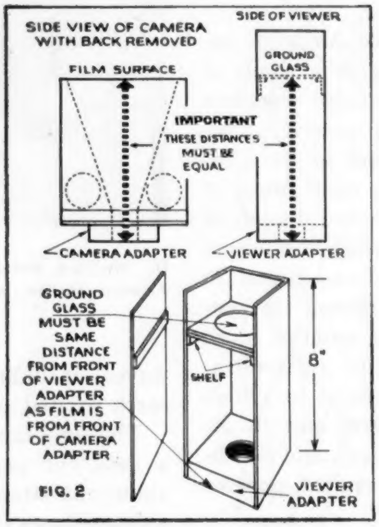
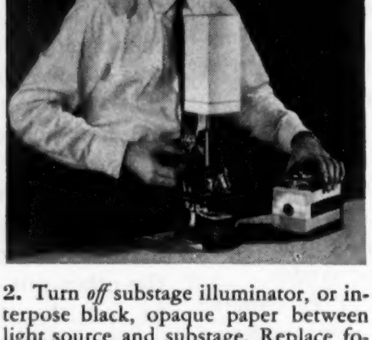


FIG. 2

PROCEDURE FOR TAKING PHOTOMICROGRAPHS:

1. Focus specimen under microscope. Be certain that the field is brightly and evenly illuminated. Then place focusing device over the eyepiece and focus microscope until image is as sharply defined as possible on the ground glass.



2. Turn *off* substage illuminator, or interpose black, opaque paper between light source and substage. Replace focusing device with camera. Set camera to time exposure and open shutter.

3. Turn *on* substage illuminator or remove black opaque paper . . . this will expose the film. After proper exposure, turn *off* substage illuminator or reintroduce black paper. Close shutter before removing camera. The camera shutter is used *only* to make the camera lightproof when it is not in use. Do not use shutter to expose film. The tripping of the shutter would create a tremor resulting in a blurred photograph. Also, be careful not to set up any other vibrations that will shake camera during exposure.

This do-it-yourself photomicrographic set-up is very convenient and very adequate. It's always ready and no elaborate adjustments are necessary.

NOTE: The following notes on microscopes, illumination and exposure are offered as guides.

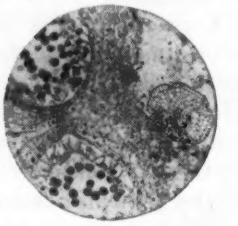


Fig. 3

A. MICROSCOPE: The microscope should be equipped with achromatic objectives and preferably, though not essential, an iris diaphragm and condenser. The AO Spencer 66 series student microscope provides just the ticket . . . its rugged, dependable and has the same mechanical and optical precision found in laboratory microscopes. If your lab already has number 66's you're all set to go ahead with your camera set-up. If not, you may want some information. Just write to American Optical Company, Instrument Division, Dept. L95, Buffalo 15, N. Y., and ask for brochure SBTI.

B. ILLUMINATION: A substage attached illuminator will guarantee the evenly illuminated field necessary for good photographs . . . the negative will show up uneveness even where the eye will fail to notice it. Here, we are using the AO Spencer 66B Microscope equipped with the low-cost 616 attachable substage illuminator.

C. EXPOSURE: Exposure is a matter of experience. If you use the microscope-illuminator set described above, you can use the following information as a guide. The Photomicrograph (see fig. 3), was taken at 100X magnification (10X eyepiece, 10X objective) with three second exposure using Kodak Verichrome Pan film. Our trials showed that one to three second exposures yielded good results. For other magnifications you can use the following rule of thumb as a guide.

1. 430X magnification (10X eyepiece, 43X objective). Expose 4 times as long as 100X.
2. 970X magnification (10X eyepiece, 97X oil immersion objective). Expose 2 times as long as 430X.

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Visual Oxidation-Reduction Reactions

By J. B. KELLEY

Department of Education, Louisiana State University, Baton Rouge

MOUNTAINS OF ABSTRACTIONS must be climbed or removed if students are to be successful in high school chemistry or the first year course of college chemistry. Teachers, too, find some mountain climbing necessary to change the abstract to real and concrete experiences for students.

The following experimental activities were developed to help students "see" oxidation-reduction reactions in a first semester college course, but they are quite adaptable to high school instruction. The experiments were successfully performed by several hundred college students under five instructors over a period of six semesters. The color changes of the reacting solutions and the formation of insoluble compounds resulting from tests of the products of the oxidation process and the reduction process are distinct and reliable.

For the convenience of instruction the experiment is organized in three parts: I—Preliminary Tests, II—Oxidation and Some Oxidizing Agents, and III—Reduction and Some Reducing Agents. Instructors may well use the suggested preliminary tests apart from the experiment when advisable. However, students should review these tests before trying the remainder of the experiment. This material may be found in most standard qualitative analysis textbooks. However, few high school teachers have access to such books, and fewer teachers of the first year college course will use their time to organize such experimental activities.

As a follow-up of the experiment, drill techniques may be employed in writing half-cell reactions, complete ionic equations, and to predict reactions from oxidation-reduction potentials. The reactions may be used for identification of oxidizing agent and reducing agents, and to determine the effect of one agent on the other.

THE EXPERIMENT: OXIDATION-REDUCTION REACTIONS

Part I. Preliminary Tests

Ferrous and Ferric Ions in Solutions

a. Prepare a fresh solution of ferrous sulfate by dissolving approximately one gram of the salt in 25-30 ml of distilled water.

b. To 1-2 ml of the ferrous sulfate solution add 2-3 drops of .5 M solution of ammonium thiocyanate $(NH_4)SCN$. Do not shake the solutions and note the results. Shake the mixture vigorously and note the results.

c. To 1-2 ml of .5 M solution of ferric chloride add 2-3 drops of the ammonium thiocyanate solution. Do not shake the solutions and note the results. Shake the mixture and note the results.

Iodine and Bromine in Solutions

a. To 5-6 drops of iodine water add approximately 1 ml of carbon tetrachloride. Shake the mixture vigorously and note the color of the iodine in the carbon tetrachloride layer.

b. To 5-6 drops of bromine water add approximately 1 ml of carbon tetrachloride. Shake the mixture vigorously and note the color of the bromine in the tetrachloride layer.

Sulfur and Sulfate Ions in Solutions

a. To about 10-12 drops of a .5 M solution of sodium sulfide add 8-10 drops of 6 N nitric acid. Warm the mixture cautiously. The off-white to yellow suspension in the mixture is collodial or suspended sulfur.

b. To 1 ml of any sulfate solution add 3-4 drops of any barium solution slowly down the side of the tube. The white ring is suspended barium sulfate. Shake the mixture vigorously and note the precipitate formed.

Nitrate Ions in Solutions

a. To 10-12 drops of .5 M solution of potassium nitrate solution add an equal volume of the freshly prepared ferrous sulfate solution. Incline the test tube and pour slowly down the side of the tube 10-12 drops of concentrated sulfuric acid. A brown ring of $FeNO{\cdot}SO_4$ between the layers of solutions indicates the presence of the nitrate ions in solution.

b. If the above test is not suitable for the nitrate tests in this experiment, one may infer if the oxidizing agent used is reduced, the nitrite ion of the experimental solution would be oxidized to a nitrate ion.

Manganous and Chromic Ions in Solutions

a. Note the color of the manganous ion in solution. This may be seen as a solution of manganous

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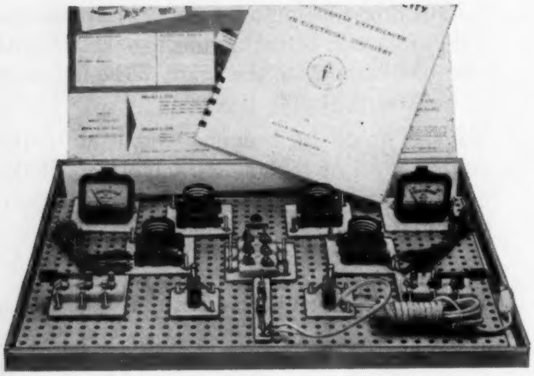

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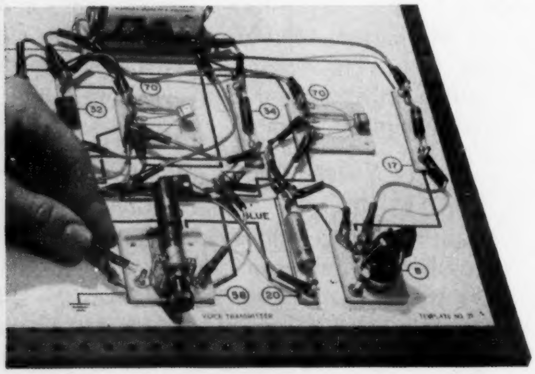

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nitrate. The pale color will not be detected in any colored solutions. Usually in acid solutions the permanganate ion will be reduced to a manganous ion.

b. The crystalline solid or a solution of chromic chloride or nitrate will show the color of the chromic ion. This color characteristic will be noted in the reduction of the dichromate ion in an acid solution.

Part II. Oxidation and Some Oxidizing Agents

a. To 2-3 ml of freshly prepared ferrous sulfate solution add 2-3 drops of phosphoric acid to acidify the solution. Then add slowly 2-3 drops of .5 M potassium permanganate solution, $K(MnO_4)$. Shake the mixture after adding each drop. Note the fading color of the permanganate solution. The permanganate ion, $(MnO_4)^-$, has been reduced to the manganous ion, Mn^{++}. Test the mixture for the ferric ion, Fe^{+++}.

b. Repeat "a," using .5 M solution of potassium dichromate, $K_2(Cr_2O_7)$, as the oxidizing agent in place of the potassium permanganate solution. The dichromate ion, $(Cr_2O_7)^=$, has been reduced in acid solution to chromic ions, 2 Cr^{+++}, is indicated by the green colored solution. Carefully test for the ferric ion, Fe^{+++}.

c. Repeat "a," (do not acidify) using as oxidizing agents (1) iodine water, (2) bromine water, (3) chlorine water. Test a portion of each solution for the halide ion and the other portion for the ferric ion.

Part III. Reduction and Some Reducing Agents

a. To 2-3 ml each of .1 M solutions of sodium sulfide, Na_2S, and of sodium sulfite, $Na_2(SO_3)$, add 1-2 drops of phosphoric acid. Then add slowly 3-4 drops of the potassium permanganate solution. Shake the mixture and note the change in color of the permanganate solution. Check the mixture which contained the sulfide ion, $S^=$, for its oxidation product of sulfur. Test the solution which contained the sulfite ion, $(SO_3)^=$, for its oxidation product, the sulfate ion, $(SO_4)^=$.

b. To 1-2 ml of .1 M solution of potassium nitrite, $K(NO_2)$, add 1-2 drops of phosphoric acid. Slowly add 2-5 drops of the potassium permanganate solution. Shake the mixture, note the fading of the permanganate color, then test for the nitrate ion, $(NO_3)^-$.

c. To 1-2 ml each of .1 M solutions of potassium iodide, KI, and of potassium bromide, KBr, add 1-2 drops of phosphoric acid. Slowly add 4-5 drops of the potassium permanganate solution. Note the reduction of the permanganate ion. Test each mixture for the halogens, iodine and bromine.

d. Repeat "a," "b," and "c," using .5 M solution of potassium dichromate, $K_2(Cr_2O_7)$, as the oxidizing agent. Note color changes of the solution containing the oxidizing agent and make test for the oxidation products.

Testing Solutions

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From Research to Classroom Laboratory...

DETERMINATION OF HALF-LIFE

A Teacher-Pupil Activity for Science Grades 7-12

T. HANDLEY DIEHL and **C. DON GEILKER**

Central High School, Cincinnati, Ohio

Radiological Training Activities, Robert A. Taft Sanitary Engineering Center

Background

THE Taft Sanitary Engineering Center has been concerned over the problem of air pollution as well as many other aspects of environmental health. In addition to the study and research programs at the center, an active training program is in progress for those who work in the field, and who will be directly associated with many of these problems. It is felt that the real meaning of half-life could not be understood by those in the training program without some direct experience. Short-lived isotopes are expensive and it is difficult to obtain them at a needed time. Mr. C. Don Geilker, who is involved with the training program, devised a method whereby the ever-present short-lived isotopes are used from the air for the experimentation-demonstration work done by the trainees. The apparatus runs approximately 4 hours prior to a laboratory period. In this way a sufficient quantity of short-lived radionuclides may be collected.

Several types of sampling equipment are available commercially. Some members of the science staff in the Cincinnati Public Schools have experimented with the use of a vacuum sweeper and filter paper to collect the samples with some degree of success.

Statement of the Problem

To acquaint the student with a laboratory method of determining the half-life of a radionuclide obtained from the air.

Equipment

Vacuum sweeper
Filter paper
Geiger-Muller tube and scaler
Lid from mayonnaise jar
Semi-log paper

Procedure

1. Place a filter paper in the hose of a vacuum sweeper so that the air coming in must be filtered before reaching the fan. (Sampling equipment may be obtained from companies listed.)

2. Draw air through the filter for approximately 4 hours. Best results will be obtained by sampling in a basement or other underground area with restricted ventilation.

3. Remove the filter paper from the sweeper and trim off the edge which did not collect any dirt. (Avoid touching the dirt on the paper.)

4. Place the sample thus collected in the lid of a mayonnaise jar and suspend over it either an end-window or side-window Geiger-Muller tube.

5. Record the counts per minute on a data sheet.

6. Repeat the count at 5 minute intervals.

7. Mark the horizontal axis of the semi-log graph paper in time units, beginning with the hour of preparation of the sample.

8. Plot the counts per minute, after subtracting

Kasha Berger Checks and Orvil Salyers Records Count per minute on Data Sheet. Teachers observing: Robert Anderson and Max Coyle.

PHS PHOTO BY DON MORAN

background, on the log (vertical) axis of the graph paper, at the correct "clock time" of the count on the horizontal axis.

9. After six points have been plotted, connect with a straight line, and determine the half-life from the graph. (Fig. 1.)

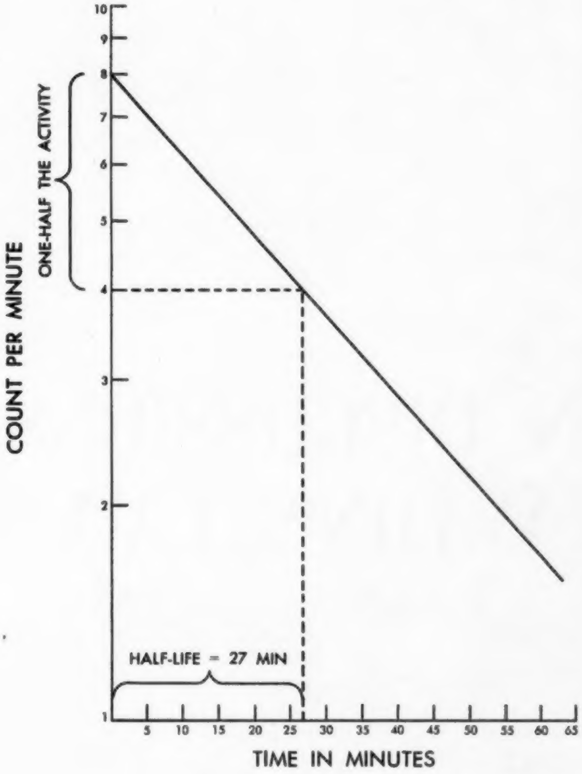

Figure 1. Half-Life Determination

(A background count for the instrument should be taken before running this experiment.)

Suggestions for Further Study

Dr. L. R. Setter of the Taft Sanitary Engineering Center has suggested placing cheese cloth in vertical and horizontal positions and permitting it to collect radionuclides from the air. Dr. Setter thinks there may be detectable difference in the activity from collecting samples in the two positions with a preferential of the vertical position collecting the greater amount of activity. If this approach is attempted, the cheese cloth would have to be charred before being counted so that the activity would be more concentrated for recording.

The authors would like to acknowledge the assistance of Robert Anderson and Max Coyle, science teachers, Woodward High School. These teachers recently completed a course in "Atomic Radiation in Science" taught by Mr. T. Handley Diehl in connection with the University of Cincinnati program.

Sources of Sampling Equipment

Gast Manufacturing Corp., Benton Harbor, Michigan Air Samplers and other equipment

Ralph M. Parsons Co., 617 South Olive, Los Angeles, California Air Samplers and Pumps

Mine Safety Appliance Co., 201 N. Braddock, Pittsburgh, Pennsylvania Hand Operated "Samplair"

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TEACHER

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R. E. Lapp and H. L. Andrews. *Nuclear Radiation Physics.* Prentice-Hall, Englewood Cliffs, N.J. 1954.

PUPIL

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ABERRATIONS IN DISCUSSIONS OF NEWTON'S LAWS

By L. W. PHILLIPS

Department of Physics, University of Buffalo, New York

PART ONE

IT requires no more than cursory inspection of high school physics textbooks to make one aware of the tremendous amount of time and energy that must have gone into their prepartion—into organization of subject matter, assembly of illustrative material, production of diagrams, preparation of questions and exercises, and into carefully worded statements and descriptions. Despite all the care taken, inaccuracies and misstatements do creep in—sometimes "new" errors, sometimes "old" ones that have been propagated from one generation of textbooks to the next, and of such long standing that successive generations of teachers and textbook writers now accept them without the thought ever arising that they might be subject to question.

Perhaps it will be thought indecent to question some of them now. On the other hand, the fact must be faced that the student sometimes draws inferences from textbook statements that would never occur to the teacher—inferences which, unless soon eradicated, become "fixed misunderstandings," lying around in the back of his mind and effectively blocking the acquisition of a correct understanding later on, sometimes quite far afield from the area in which the block developed. A student may have difficulty in understanding a particular principle because, sometime in the past, he acquired an incorrect idea which contradicts it. Maybe the incorrect idea is only a vague one—maybe he can't exactly put his finger on it himself—but it's there, and it confuses him. Such misconceptions are even more difficult—in many cases impossible—for a teacher to ferret out and eliminate. For example, the student who misunderstands the meaning of "unbalanced force" when he first hears of it—usually in connection with Newton's Laws of Motion—is going to be plagued forever after whenever an unbalanced force is involved. An incorrect under-

standing of the "reaction" forces of Newton's Third Law is an even greater burden. Of course there is no way to insure that no student will ever get an incorrect idea firmly fixed in his mind; the best one can do, perhaps, is to make every possible effort to eliminate incorrect statements and statements which, though correct as they stand, give the student liberty to draw an incorrect inference.

There seems to be general agreement among textbook writers that Newton's Laws of Motion are of sufficient importance to deserve careful treatment, usually fairly early in the physics course. Not always are the statements of the laws, nor the examples chosen to illustrate them, as clean-cut as they might be. This is *not* intended as a preface to an edict, "Newton's Laws *must* be stated *this* way." It is not being suggested that there *is* any *one* way to state Newton's Laws. It is suggested, though, that there are some statements in print that do not say what Newton intended the laws to say, and that there are some illustrative examples cited which lead to misunderstanding rather than to understanding of the laws. It is further suggested that high school teachers should be aware of the "aberrations" and should take some pains to nullify or eradicate false impressions created.

This article is not intended to be merely a compendium of quotations of "bad physics," but the quotations are here because they serve to point up the problem that high school teachers face, and because they facilitate discussion which it is hoped will help to clarify what seem to be at present some not-very-well-understood points.

The First Law

Most textbooks state the first law, "An object at rest remains at rest, and an object in motion . . . etc" but one finds in several of the currently-popular books a variant of the statement which is misleading—a variant in which the word "tends" appears, so that the law comes out essentially thus:

> "An object at rest tends to remain at rest, and an object in motion tends to remain in motion at constant speed and in a straight line, unless it is acted upon by an unbalanced force."

Phrased in this way, the statement implies that once an unbalanced force is applied, the "tendency of an object to maintain its state of motion" (that is, the body's inertia) disappears. This, of course, is *not true*. The tendency of a body to maintain its state of motion remains *even when,* not *unless,* it is acted upon by an unbalanced force. Replacing the words "tends to remain" by the single word "remains" will make the statement correct.

Normally, following the statement of the first law one finds a description of some familiar examples, and a discussion in which the words "inertia" and "mass" appear—sometimes only one of them (usually "inertia"), sometimes both, and when both words are used, there is usually an attempt to tie the two concepts (*two* concepts?) together, but a very definite reluctance to say that "mass" and "inertia" are the same thing. One finds mass defined without any reference to inertia:

(a) "The mass of a body is the quantity of matter in it." ". . . mass, which is the amount of matter contained in a body."

(b) "Mass refers to the quantity of material in an object, or the condensation of its molecules. Some forms of matter have greater mass than others, for the molecules are closer together. In general, solids have greater mass than liquids, and liquids have greater mass than gases."

or one finds some admissions that mass and inertia have "some connection" with one another:

(c) "Inertia determines mass."

(d) "A measure which clearly interprets inertia is mass."

(e) "Inertia, like weight, depends greatly upon mass."

or the clear implication that mass and inertia are two entirely different things, when, in a tabulation of the properties of matter, one finds two headings:

(f) "Mass a Second Property of Matter" and "Inertia a Fifth Property of Matter."

Statement (a) is not at all uncommon, despite the blind alley into which it leads. If this is to be the definition of mass, then one is bound to explain what "quantity of matter" means and how it is to be measured, and one soon gets trapped into defining quantity of matter (i.e., mass) as the product of volume and density, and into thereafter defining density as mass per unit volume—a vicious circle from which there is no escape. The second part of statement (b) appears to make "mass" and "density" synonymous. One can make the statement that, in general, solids have greater *density* than liquids, and liquids greater density than gases, but certainly the volumes of the materials involved must be specified before one can make the same statement about their respective masses.

Statements (c), (d) and (e) assert a connection between mass and inertia, but one detects a distinct reluctance on the part of the writer to be so bold as to say that they *are* the *same thing;* and the headings in (f) clearly say that they aren't.

Is there really any necessity for this circumlocution—mass "interprets" inertia, or inertia "determines" mass? Inertia is a convenient word to use

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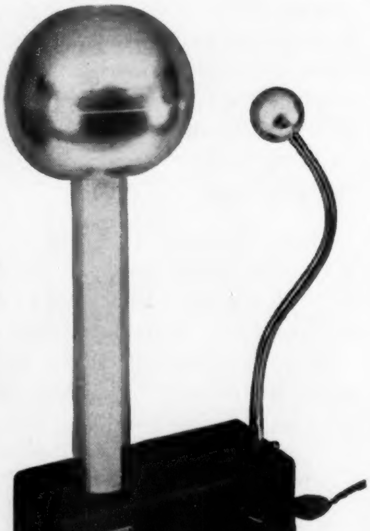

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in discussing the tendency of an object to maintain its state of motion, but once the "inertia-property" has been discussed, can't one introduce the word "mass" as just another name for it? And is there any objection to driving the identity home by using the words interchangeably thereafter; at times speaking of, say, an object with a "mass of 5 pounds" as one which has "an inertia of 5 pounds"?

Almost all books take some pains to point out that a moving object, subjected to no resisting force, continues naturally in its state of motion—that it does not require a force to keep it going. This is not something that a student accepts readily; he has to be convinced of it. Textbooks do a pretty good job of making the first law seem completely reasonable, but then doesn't an author reveal a certain lack of conviction when he says

> "If one leaps from a rapidly moving car, he is likely to fall in the direction in which the car was moving because *inertia pushes* his body forward."

or,

> "A train picks up water, because the inertia of the water forces it up into the tender."

Inertia does not *push* the leaper; to maintain his state of motion *requires no push;* until he makes contact with the ground *nothing* (except the air through which he moves) *pushes* on him. He falls because, when his feet finally do touch the ground, the ground pushes *them backward*. And inertia does *not force* the water up into the tender; the force to do that is supplied by the scoop.

The Second Law

There are almost as many versions of the second law as there are textbooks, some relating force to the time rate of change of momentum, some relating force to both mass and acceleration, and some presenting the law as a relation between force and acceleration, mass being ignored. How an author chooses to state the second law is usually consistent with the general level of the rest of the book. The points to be considered here are not concerned particularly with the statement of the second law (though the second law is certainly incomplete if inertia is ignored) but are concerned with some of the associated discussion—in particular with what is said about "external" or "unbalanced" force, and with what is said, usually along with discussion of the second law, about "mass and weight."

More than a few students get the idea that by "the unbalanced force" acting on an object one means "the largest" of the forces acting on it—that given a set of forces, one gets the unbalanced force by picking out of the set the biggest one, and that the direction of the unbalanced force is the direction of this "biggest" force. This certainly seems to be implied by a paragraph such as this:

> "What do we mean by an unbalanced force? If we have two forces of 10 pounds pulling against one another, as in an absolutely equal tug of war, each force balances the other and there is no motion to either side. But if one force is changed to 20 pounds, this force, being greater than the other, is not balanced by it. Hence motion takes place in the direction of the greater (or "unbalanced") force."

It is quite true that in this case the motion does take place in the direction of the greater force, but the "unbalanced" force is not, as the parenthetical note implies, synonymous with the *greater* force. The unbalanced force is the sum (vectorially) of the two forces—that is, the *resultant* of the two forces. What the above paragraph implies is said more specifically in another text:

> "The acceleration of any body is directly proportional to, and in the direction of, the greater unbalanced force acting on it."

Even if one never considers any but parallel forces, what one means by the "resultant" of a set of forces must be made clear, and the "unbalanced force" of the second law clearly identified with this resultant force, not the biggest of individual forces.

Sometimes it is in some earlier section, sometimes in connection with discussion of the second law, that the "weight" of an object is defined—as the "pull of the earth" or the "gravitational attraction" of the earth on the object. Although this definition seems to be straightforward enough, one finds statements that imply that the situation is really much more complicated than this:

> "Weight depends on two things, the earth's attraction for the object, and the quantity of mass. . ."

True, the weight of an object does depend on its mass, but it does not "depend on" the earth's attraction; it *is* that. Further, if one speaks of "the quantity of mass an object contains," isn't there a danger of creating the impression that mass is something like sugar or sand, that can be poured into or poured out of an object, its mass at any one time depending on how much happens to have been poured in or poured out at that particular moment?

And another statement:

> "Everywhere on the earth's surface there is an unbalanced force which pulls objects downward toward the earth's center. Newton called this force which the earth exerts on all objects the *force of gravity*. When acting on objects, the force of gravity is called *weight*."

(Continued on page 468)

The Science Involved in Rocketry

(Describing a Short Course for Teachers and Sponsors)

By H. H. BLISS

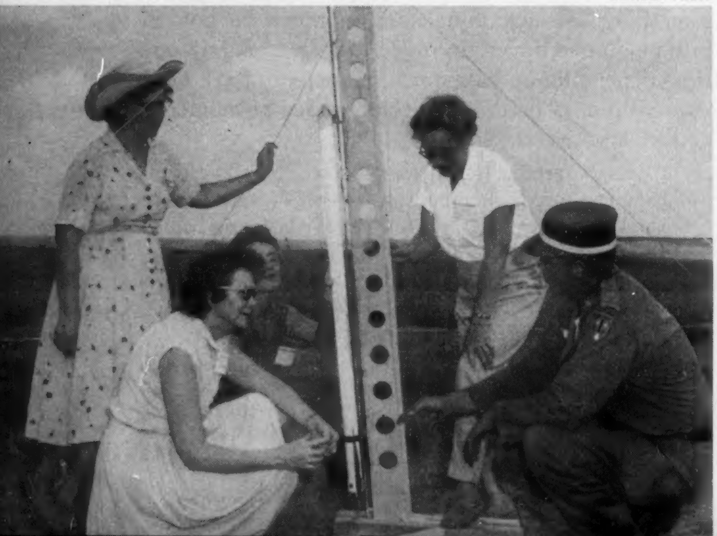
University of Oklahoma, Norman

"GENERATIONS FROM NOW we may be measured by the guidance and leadership which we are providing for the budding scientists who now sit in our classrooms. . . . Boys and girls both are curious and their curiosity must be satisfied. Here is where our generation meets the test; either we lead and guide them along the safest path possible or they will move out on their own. We must channel their energies in directions which will produce positive results by which they can measure their progress and we must so constrain them that they will not get hurt. Through it all we must never let them think that we are holding them back. If we do, we will throttle their curiosity and will lose the progress which they are sure to attain as their interest increases."

The above quotations from the banquet address of Colonel H. L. Sanders, Fort Sill, keynoted the philosophy of the only week-long short course on amateur rocketry so far reported. Many rocketry courses are now being offered either as intensive short courses or as weekly lectures aimed at those scientists, civic and governmental leaders who are moving into this rapidly developing field. This one short course however given at the University of Oklahoma in August 1958 represents the only known effort to pitch instruction to teachers and associated community leaders faced with the problem of helping the youth of our country learn about a subject in which many of them are intensely interested. Some students were admitted to the course on a trial basis and the mixed class of students and teachers proved to be quite successful. Ten persons received tuition scholarships through a grant from the Boeing Airplane Company.

Teachers Houghtaling, Buzbee, Jones and Coogan place rocket on launcher as Captain Harris directs.

US ARMY PHOTO



Colonel Sanders, Director, Department of Materiel, U.S. Army Artillery and Missile School, Fort Sill, Oklahoma, stated clearly the basis for cooperation between military establishments and civilian groups. Briefly, civilian direction in the research and development of amateur rockets can be carried out in any location up to the point of loading (fueling) the rocket. The military establishments having adequate range facilities can assist in the remainder of the rocket program by supervising the propellant loading and launching.

The problem for civilians then becomes one of assuring the military that adequate planning, preferably with some pre-test of components, has been carried out before the rocket is brought to the military establishment, so that the actual firing may be as beneficial as possible.

The University's course of instruction was able to utilize this experience at Fort Sill after obtaining approval of the Commanding General, Major General Thomas E. de Shazo. The exceptional experience in training military units to handle missiles made an invaluable contribution to the planning of the special course by Colonel Sanders and three of his officers, Captain Judd T. Harris, Jr., Captain Luke A. Vavra, and Captain Robert J. Ellison. Other members of the planning committee, Bruce V. Ketcham, Chairman of the School of Aeronautical Engineering, and Luther E. Lewis, Jr., a classroom teacher at Southeast Junior-Senior High School, Oklahoma City, added school and college teaching experience. Professor Ketcham pointed up the basic relationship of missiles and rockets to aeronautical engineering. Mr. Lewis' experience included sponsorship of the Oklahoma City Rocket Research Society and coordination of student groups from twenty affiliated high schools in the area.

The course started with a lecture on the history of rocketry by Captain Ellison. It might be noted that Goddard's proposals for the use of rockets illustrates the determination of an indi-

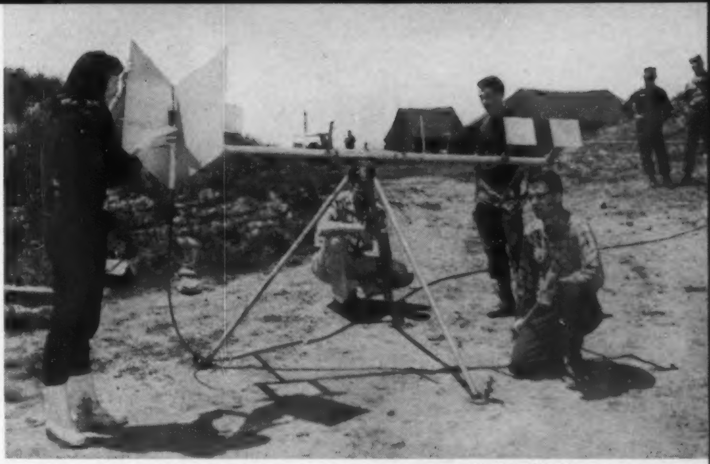
vidual to establish facts and relationships in spite of great odds. It was possible to show that while the foresight of a pioneer is often discounted by his contemporaries, ultimately it proves him to have been an invaluable worker.

Professor Ketcham discussed the principles of propulsion, pointing out that an engine produces thrust by ejecting particles at extremely high velocities. Terminology such as thrust and specific impulse were defined in this lecture.

Special lectures were given by Professor L. A. Comp of the School of Aeronautical Engineering and Mr. John Keller, chemical engineer in the solid fuels section of the Research and Development of Phillips Petroleum Company. Mr. Keller outlined the different types of propellants (fuels and oxidizers) and defined a number of the properties and safety considerations used in the development of propellants. Inasmuch as Oklahoma amateur practice has settled on the zinc-sulfur combination as a propellant until more adequate propellant test facilities can be developed, Mr. Keller discussed some of its special properties.

Captains Vavra, Harris and Ellison used the basic design of an amateur zinc-sulfur rocket as a typical engineering design problem. The mathematical calculations leading to the selection of materials, nozzle and chamber dimensions and other factors were presented. The mathematics used was held to the level of algebra, plane geometry, and trigonometry as much as possible. Review preparation for the design problems was conducted in an optional evening session on mathematics.

The highlight of the week was an all day trip to Fort Sill to fire rockets evolved from the classroom design problems and to see a number of student rockets fired. Also, prior to going to the range, the class was shown teaching facilities at the Artillery and Missiles School. The firing at the range was conducted as a typical amateur shoot. About fifty military personnel were on duty with assignments such as first aid crew, fire fighting detail, explosive demolitions squad, radar crews and safety officers. Mixing of the powdered propellants, the weighing of components, and the assembly, mounting on the launcher; and actual firing of the rockets from the control bunker were all participated in or observed by the class. Observations were made from observation slits in reinforced concrete bunkers on the artillery range. Artillery counter mortar radar followed the flights and provided performance data on the rockets within about five minutes after firing. A demonstration was conducted in the handling of misfires and two rockets were constructed to explode on



US ARMY PHOTO

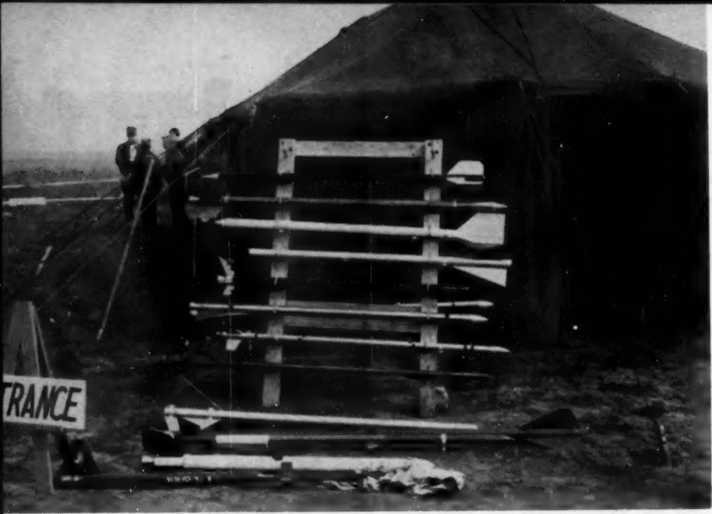
University of Texas rocketeers line up the tracking system to pick up signals from the nose cone transmitter of their experimental rocket.

firing. These failures pointed up the importance of proper design and dramatically illustrated the danger to unprotected property and personnel. All rockets adhering to the design criteria discussed in previous classes were successful and attained altitudes ranging from five to seven thousand feet. The firings provided data for class use the following day in a lesson on the analysis of test results and indicated redesign.

Mr. Lewis held two seminar sessions of special importance to teachers. One, on the curricular use of rocketry, emphasized the motivational values for students in regular high school courses, particularly algebra, geometry, trigonometry, physics, and chemistry. In the other, on the extra-curricular use of rocketry, he suggested that emphasis be placed on the organization of clubs for research and training practice. Students can specialize in some phase of rocketry when working as a team with others of like interests. Such organization also gives good experience in the coordination of efforts through team work such as is involved in professional rocketry. Mr. Lewis' extensive experience formed a very valuable part of the course, bringing the subject down to cases for teachers by showing them how to use available information in classroom and club situations.

Materials used and/or produced especially for this short course included student-built rockets, mimeograph lecture notes for most of the session, recovered rockets including some that had exploded, and a booklet, "A Guide to Amateur Rocketry." This latter booklet, available by writing the Commanding General, Fort Sill, Oklahoma, served as the basic text for the design portions of the course.

In evaluation, teachers and students were nearly unanimous in crediting the course for developing their own insights and giving them sufficient background for using rocketry in developing motivating activities for their students, both in and out-



US ARMY PHOTO

Rockets of various designs ready for launching.

side the classroom. Students reported having a better respect for learning the fundamentals of science and mathematics. Undoubtedly, dividing responsibility by assigning loading and launching supervision to the military establishments, reassured teachers that reasonable safety could be maintained. The course also demonstrated that students and teachers could learn together without embarrassing each other. The presentation of the rocket design problems in which different factors were dealt with separately and then combined into a vehicle for testing, analysis and redesign illustrated a typical engineering job. This helped clarify the nature of engineering work, something often cited as poorly understood by teachers and students alike. And finally, safety was emphasized throughout and thoroughly demonstrated on the artillery range.

What are the next steps in this development? Fort Sill will continue to hold launchings at approximately one-month intervals. Arrangements are made directly with the Commanding General. Aeronautical Engineering majors at the University are probing the possible functioning of their student chapter of the American Rocket Society in an assisting program. A static test stand is being built on which different design factors can be tested without launching, so a pre-flight service can soon be offered to the students of the area. The School of Aeronautical Engineering is exploring the possibility of a credit college course for their majors. It is quite possible that the teachers' short course will be re-offered in June 1959 perhaps with an optional second week advanced course to follow. An adaptation of the basic course to correspondence study to make the experience available elsewhere will be ready soon. And finally, the group asked for some mechanism for the distribution of information, probably in newsletter form that they might keep in touch with one another.

A SCIENCE-ECONOMICS WORKSHOP

By CHARLES BREEDLOVE
Detroit, Michigan Public Schools

LeVAN SHUGART
Palo Alto, California Public Schools

ALDEN SMITH
Greenwich, Connecticut Public Schools

A SCIENCE-ECONOMICS WORKSHOP was held at Sarah Lawrence College, Bronxville, New York from August 2 to 22. This national workshop was under the joint sponsorship of the National Science Teacher's Association, the National Council for the Social Studies, and the Joint Council on Economic Education.

Thirty-three teams, each consisting of a science teacher and a social studies teacher, were invited from thirty-three school districts in fifteen different states. This group, under the guidance of a fine staff, spent the three weeks making a study of "The Impact of Contemporary Scientific and Technological Developments upon Our Economy."

More than twenty visiting lecturers gave lectures and worked in small group meetings. The five areas of applied science chosen for study were Energy, Health, Automation, Space, and Food. Each topic was introduced by a scientist in a formal lecture which was followed by a question period at both the committee level and before the entire workshop. Each of these presentations was followed by a lecture by an economist on the economic and/or social impact on society.

On days following the formal lectures, the workshop was separated into five groups representing the various geographical areas that participated in the conference. Group discussions centered on the implications for curriculum and instruction, in both science and social studies, of the information and concepts presented in the lectures. The groups also considered means of effecting desirable changes in these two areas. Following this, the individual school teams drew up specific ideas for devising an effective program in their own schools.

It was agreed that science teachers will include new social and economic concepts related to their work in their courses, and that the social studies teachers will incorporate new scientific developments as they affect their areas of study. Many areas of cooperation were found in which the teammates might serve as consultants to each other during the ensuing year. Some of the teams will be teaching common groups of students and are planning very close coordination. Numerous other devices were suggested by means of which other teams may cooperate.

Two of the plans which are to be placed in operation next year are described briefly below.

The Palo Alto team of Lois Walsh and LeVan Shugart will be working with the same group of thirty students in successive class periods. Their aims are to help the students realize that learning does not stop at the arbitrary lines established by course titles such as United States History and Advanced Biology. These teachers hope that the students will recognize an interdependence between their subject areas as well as between other subject areas based on related and overlapping concepts.

This they hope to accomplish in the following manner. The scientific approach to problem solving will be introduced in both classes at the same time. This will be followed by an historical approach to the background of both areas. From this beginning, with similarities between two subjects, each teacher plans to make cross references to basic concepts in his colleague's field. Basic concepts, terms, skills, and attitudes which they believe to be essential to this program have been identified by the teammates. The successive periods will facilitate the common use of community resources such as speakers, field trips, and other projects which require an extended period of time. The students will be doing joint work with credit for both.

Each teacher will evaluate the student's advancement in his area as usual and the team will evaluate the "bridging advancement" that the students demonstrate relative to the aims set forth above. One device that now they have agreed to use is an extensive problem involving the efficient use of renewable resources and funds available from various

sources for use in solving the problems facing a flooded area. This will test the student's ability to recognize, analyze, propose, and support a solution to these problems. The team plans to keep an annotated record of the results of their efforts.

The Detroit team of Charles Breedlove and Carl Wheaton will be cooperating in the areas of chemistry and economics. They will have no common students, but plan to make use of joint committees, exchange of teachers, reports, joint field trips, educational films, and student demonstrations. Since Michigan's economy is largely based on the iron and steel industry, it was thought that they had an excellent opportunity to coordinate their work in the fields of metallurgy and production in heavy industry. Certain implications due to cheaper methods of processing of non-ferrous metals and the dwindling supply of high-grade iron ore in the Mesabi Range of Michigan and Minnesota will be stressed. The importance of the St. Lawrence Seaway and the new mines in Labrador will not be overlooked. They feel that the rather large drug industry in Michigan offers another excellent opportunity for study by students in the chemistry and economics classes.

During the last two days of the workshop a carefully planned evaluation was carried out by a special committee. A careful tabulation of the findings of this committee seemed to point out the value of future workshops in this area, and the need for a follow-up study by members of the 1958 workshop. A system for sharing of experiences by members includes a newsletter, which will be collected and edited by a committee, regional conferences during the coming year, and visits to the various schools by staff members. The evaluation report seemed to indicate that a large portion of the members felt it was their duty to disseminate information about this type of cooperation between the science and social studies departments to other members of their own schools and, where possible, to teachers in the other schools in the system by established channels of communication.

Some of the general underlying concepts that grew out of the conference were these:

► that learning cannot be compartmentalized any more than one's life can be divided into various sections;

► that scientists and science teachers must recognize their responsibility to other disciplines;

► that all must accept social responsibility for the economic and social consequences of the use that is made of the products of science and technology.

SIX FULL HOURS

Tune of Sixteen Tons

Some people say a teacher is made out of steel,
Their mind can think but their body can't feel.
Iron and steel and hickory tea,
Frowns and gripes from nine to three.

You teach six full hours and what do you get?
Another day older and deeper in debt.
You pay your debts and for this and that,
Then for 29 days your billfold's flat.

I was born one morning when it was cloudy and cool.
Picked up my lesson plans and headed for school.
I wrote 35 names on the homeroom roll
And the Principal said, "Well, bless my soul."

You teach six full hours and what do you get?
Gray hair, circles, dirt, and sweat.
I got stepped-on toes and can hardly walk;
When I turn my back, then comes the chalk.

I got 35 kids and 29 seats;
Twenty are talking while 15 sleep.
I can hardly get 'em all through the door,
And if I don't watch out they'll send me some more.

The last bell rings and I start for the door;
My head's a-ringing and my feet are sore.
I taught six full hours, my day is made;
But I still have 90 papers to grade.

You teach six full hours and what do you get?
Another day older and deeper in debt.
I'll go to St. Peter, but I just can't stay—
I gotta come back for the P. T. A.! ! !

GERALD MALLMANN
Fox Valley Lutheran High School
Appleton, Wisconsin

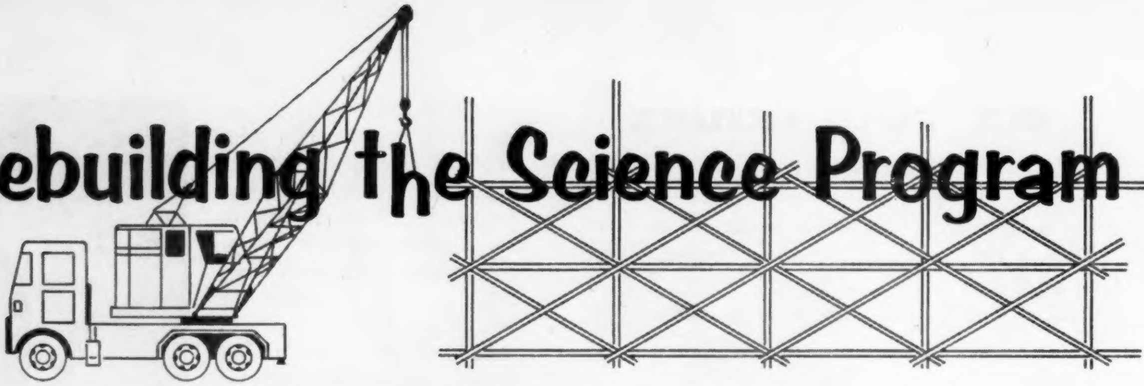
P. S.: You know, of course, that this couldn't happen to a science *teacher because of the subject matter in which he deals.*

HESSLER STUDIO, WASHINGTON

Lyle W. Ashby, assistant executive secretary for educational services, has been named deputy executive secretary of the National Education Association. Dr. Ashby has been with NEA since 1928, and will assume his new post on January 1. A native of Guide Rock, Nebraska, Dr. Ashby attended public schools there and received his A.B. degree at Hastings College, Hastings, Nebr.; his master's degree from American University in Washington, D. C.; his doctorate from Teachers College, Columbia University; and also received an honorary LL.D. from Hastings College.

Dr. Ashby has an active professional background in educational services having served as liaison for 26 NEA departments; directed regional instructional conferences in many state areas, and planning NEA convention programs. NSTA offers congratulations to the new oppointee, and commends NEA on the selection.

Rebuilding the Science Program



Concerning Ninth-Year Biology

By PHILIP GOLDSTEIN

Chairman, Department of Biology, Abraham Lincoln High School, Brooklyn, New York

This article or letter-style essay carries, perhaps, an important caution to those who would hastily and drastically redesign the science curriculum by *armchair* quarterback procedures. This I say on general principles and not in terms of pro or con on 9th- or 10th-grade for beginning biology. NSTA, incidentally, has taken no official position thus far in various debates centering on grade-placement of courses.
Editor

FOR many years, biology has been considered to be best placed in the tenth year of the science sequence, followed by chemistry and physics in years 11 and 12. Suddenly there is a great deal being said about moving biology down into the ninth year, in order to make room for more advanced electives in the twelfth year. It is becoming increasingly apparent that this idea is being fostered and pushed in certain quarters over the objections of many science teachers. Therefore, I should like to get my oar into this controversy before it goes much further.

But before I say my piece, I should like to make clear that I am no Johnny-come-lately to the field of science teaching. Nor am I a college teacher with little or no contact with what goes on in high school science teaching. I have spent the best 27 years of my life teaching biology and other sciences to assorted high school pupils in four New York City high schools (including six years at the Bronx High School of Science). In addition I have done a little college teaching on the side. For the last nine years, I have been chairman of the Biology Department at Abraham Lincoln High School in Brooklyn, N. Y. I am the author of two books which are used in many high school science classes, as well as an assortment of workbooks, articles, syllabi, etc., in the field of science teaching. One of my articles was awarded a first prize in the Science Teachers Award Program of NSTA several years ago, and on two other occasions I have been awarded honorable mentions.

And now that I have given my credentials, I hope that I have established my status as an expert witness. Therefore, I now feel ready to present my testimony. I would like to recount the events which led up to my being an unsuspecting pioneer in the movement for ninth-year biology, and then to draw some conclusions from my experience.

How I Became a Pioneer

Some time ago, my principal invited the two science chairmen of the school to meet with him on the question of what we could do for our outstanding science-minded students. He was interested in developing a super-duper science program for a small group of special students who would get more than just the usual four-year science sequence consisting of general science, biology, chemistry, and physics. After we had kicked various thoughts around for a while, I finally proposed a plan which met with the approval of the principal, the physical science chairman, the administrative assistant, the program committee, and powers that be.

Essentially the problem was one of program space. We already had plans for a course in experimental biology, another in laboratory techniques, one in college physics, and even a shop course for these special pupils. The big problem was how to squeeze them into an already loaded program which our bright pupils carry. My solution was simple. I urged that for these selected pupils who were going to take all the high school sciences anyway, we could very well omit the general science in the ninth

year and start them right off with biology. Then we could follow this up with chemistry plus experimental biology and shop in the tenth year, physics in the eleventh year, and that would leave the twelfth year open for college physics, laboratory techniques, or any other science electives that we could devise. And so, in all innocence, I became a pioneer in the ninth-year biology movement.

Of course these were bright pupils—hand picked. Every last one of them was highly recommended by previous teachers. Each applicant for the course had a high I.Q., a good reading score, a good arithmetic score, and a high standing on the Iowa tests, so there was little question about basic ability. On top of this we called meetings of the applicants for the course and their parents to explain that this was to be a difficult course which would require lots of work. And into the class finally went only pupils who wanted to become a part of this program, and whose parents agreed.

But then something else happened, which had no relationship to this special program, but which in retrospect takes on great importance. It was sheer accident, but when my teaching program was made up, not only did it carry this special ninth-year biology class, but also one of our regular tenth-year honor classes in biology. This class was also made up of bright students, but these were tenth-year students. So by the sheerest of accidents, a controlled experiment was set up. Here were two parallel classes made up of selected students, both being taught the same material by the same teacher, and both being tested at the end of the year by the same statewide Regents Examination. There was only one difference between the two classes. One class consisted of ninth-year pupils, while the other consisted of tenth-year pupils, so that there was an average age difference of one year.

What Happened

I had no idea at the time that I would want to compare ninth- and tenth-year biology. Therefore I kept no records to compare reactions of these two classes. However, certain subjective conclusions forced themselves upon me. These I will state later on in the article. But results on the New York State Regents Examination are a matter of record, and I can look back at this objective record and make comparisons. So, let us examine the Regents results of these two classes, keeping in mind that they both learned the same material under the guidance of the same experienced teacher (namely me), and that they both took exactly the same examination under exactly the same conditions.

To begin with, let us take a look at the distribution of the grades scored on the regents examination by the members of the two groups under consideration. These figures are presented in Figure 1 below.

DISTRIBUTION OF MARKS ON N.Y.S. REGENTS EXAMINATION IN BIOLOGY—JUNE 1958

Mark on the Regents Examination	Number Receiving This Mark			
	9th year class		10th year class	
100	0		1	2.6%
95–99	6	18.8%	17	44.7%
90–94	6	18.8%	11	29.0%
85–89	9	28.1%	5	13.2%
80–84	2	6.3%	2	5.3%
75–79	4	12.5%	2	5.3%
70–74	0			
65–69	4	12.5%		
35–39	1	3.4%		
Total	32	100.1%	38	100.1%
Mean	84.7		93.0	

Figure 1

Without recourse to any detailed statistical analysis it seems immediately evident that the 10th-year group did far better on this examination than did the 9th-year group. Just one look at the distribution curves of the two groups (Figure 2) will show this clearly. (Note that in the 9th-year curve, the case which fell between 35 and 39 has been omitted since it is so far off the curve that it is abnormal.) Since the number of students in the two groups is not equal, the curves are plotted in terms of per cent of the group getting a given mark on the regents examination.

Now consider the means of the two groups. The ninth-year group had an average score of 84.7 while the tenth-year group averaged 93.0. This gives us an average difference of 8.3 per cent in favor of the tenth-year group. Is this a true difference, or is it due to chance alone? To test this, we calculated the standard error of the difference and found it to be 2.4. The ratio of difference to standard error of the difference (8.3/2.4) is equal to 3.46. By reference to the appropriate probability table we can see that in so far as our groups are representative, and in so far as our test is valid, this is a true and reliable difference between ninth- and tenth-year groups. There is only one chance in 3600 that a difference in favor of a ninth-year group will turn up if this experiment is repeated.

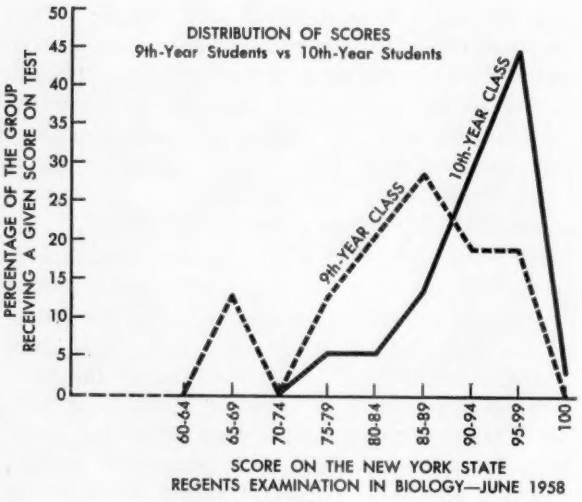


Figure 2

Next, compare if you will, the per cent of ninth- and tenth-year students that stand in the top half of the total group. Calculation shows the median score to be 91.6 per cent. By reference to figure 3, you can see at once that of the ninth-year group, only 10 students out of 32 (31.3 per cent) scored higher than the median score of the whole group. But in the tenth-year group 25 out of 38 (65.8 per cent) of the students stood above this median score. Thus more than twice as many tenth-year students are in the top 50 per cent of the group than ninth-year students. If we consider the top third of the total group the ratio is even higher in favor of the tenth-year students.

Observe just one more fact. About 15.6 per cent of the ninth-year group scored lower marks on the test than any one in the tenth-year group. This can be seen by referring back to Figure 1. All in all, from whatever angle these results are examined, there seems to be a significant advantage for the tenth-year biology student over the ninth-year one.

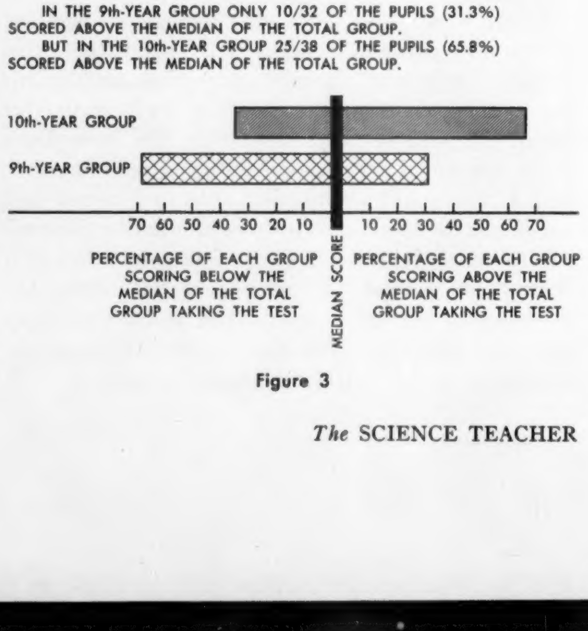


Figure 3

My Interpretation

I will grant immediately that this accidental experiment includes but a small number of cases. It needs repetition with larger numbers, and on a planned basis rather than as an accident. Still, the results are so surprisingly startling that they cannot be brushed off and overlooked. Frankly, as the marking of the June 1958 regents examination was completed, and as I first began to record the grades, I was horrified at the poor showing made by my selected ninth-year class. Their achievement on this test seemed far below the standards I have become accustomed to expect from honors classes. But a little mature reflection showed me that I should not have been so surprised. There were indications right along that everything was not as good as it should be. There were danger signals many times during the term—poor grasp of theoretical concepts, unsatisfactory approach to individual and group reports, and other such things. But I just wasn't looking for these danger signals.

I have reached the conclusion that although there is only one year difference chronologically between ninth-year and tenth-year students, the gulf which actually separates them is tremendous. The difference in maturity is much greater than the year difference in age. A boy or girl fresh out of elementary school at the age of 12 or 13 (and our bright pupils do reach ninth year at this age) is still figuratively a baby. But by the time he has spent a year in high school, he has grown tremendously—he has developed from a child into a teenager, with a completely new outlook and understanding. That year of maturation, experience, and growth makes all the difference in the world.

So, when I applied the same teaching techniques and procedures to this class that I have always used with honors classes, they were not really ready. They had not yet reached the state of maturity necessary for this approach to a subject. They were no more prepared for it than are our high school seniors when they suddenly change to college freshmen and face still another approach to learning. College teachers of freshmen will appreciate this.

Still, despite this lack of readiness, this special group was not so bad when the work was of a factual nature. They could learn names or structures. Perhaps they had to work a little harder than the tenth-year students, but they could do it. They began, however, to show definite signs of weakness when we began to deal with more theoretical matters such as genetics, eugenics, and evolution. In theoretical concepts they could not hold a candle to the tenth-year students. Their discussions of these things revealed immediately that they were far less mature than necessary to appreciate and understand what was beneath the surface in these subjects.

Conclusion

So, having been an innocent and unwitting pioneer in the move to push biology into the ninth year, I am forced to conclude that it is not such a good idea. I do not think that high school freshmen are mature enough to study biology—*at least not the biology we teach today in New York City.*

Oh yes, I could write a course of study for ninth-year biology. But there would be so much that I would have to leave out! I remember very distinctly the days before general science became a constant. We used to teach two years of biology—elementary biology in the ninth year and advanced biology in the tenth year. Our elementary biology was a very interesting and popular course. But what a difference from the advanced course. There were few theoretical concepts in the elementary course, because it was assumed, and rightly so, that these students were not yet ready for high level concepts. All of these were reserved for the advanced biology course.

Should we today go back to the old elementary type of course which is suitable for ninth-year students? I should hope not. I would oppose this move with all the power at my command. I conceive of such a move as a retrogressive step of the worst kind. Certainly it is not for the greatest benefit of our science-minded students. I cannot conceive of a student with a well-rounded science education who has never learned a little about how he inherits traits and passes them on to his children. Nor can I picture a well educated person who does not have some understanding of the concept of evolution, or of the unity of all races of mankind. And this would be the inevitable outcome of a return to ninth-year biology of the kind we once taught. Ninth-year students are just not ripe for these concepts.

And just one parting remark—for those who are pushing the idea. Remember, just as tenth-year biology is not suitable for ninth-year students, so eleventh-year chemistry or physics is not suitable for tenth-year students. That one year of difference in experience will still be there. The result will be that the physical sciences will also have to omit many of the important theoretical concepts if they are to be successful with tenth-year students. And will this achieve the aim which is in theory the motive behind the move towards demoting biology?

Extending the Science Curriculum

By SUMNER T. SCOTT

Mankato, Minnesota High School

This report was an entry in the 1957-58 STAR (Science Teacher Achievement Recognition) awards program conducted by NSTA, sponsored by the National Cancer Institute, U. S. Public Health Service.

THE intent of this paper is to show how senior high school science teachers can extend their efforts (1) to include the elementary level, and (2) to apply science education successfully at the adult level.

The Elementary Level

Over a period of time it was realized that in our school system [1] great opportunities existed to extend the teaching of science at the elementary level if grade school teachers were given help and encouragement. Consequently, the elementary supervisor was approached with an offer of help and advice in the form of laboratory science lesson plans and a science apparatus kit. This idea was enthusiastically received.

The next step was to develop the lesson plans with regard to content and presentation. The lesson plan itself was aimed at the teacher in the belief that she was better qualified to present the material in accordance with accepted methods in elementary education.

The lesson plans, then, were designed to serve as resource material for the teacher. Furthermore, an effort was made to produce lesson plans that would be comprehensive enough to be applicable, at least in part, to all elementary grades.

Each lesson plan was developed in the following manner: (1) title, (2) objectives, (3) materials, (4) discussion, including ideas and concepts to be developed, suggestions by which main ideas could be developed and the procedure for demonstrating the laboratory apparatus, and (5) applications.

The science kit itself included the necessary equipment to develop each lesson plan. The box for the kit was made according to specifications by the vocational department of Mankato High School as a class project. Physically, it resembles a suitcase with a handle for easy transportation and clasps to secure it. It rests on its side and opens like a book. It has shelves on the inside to hold the various pieces of apparatus.

Resource material in the form of excellent science texts and references is commercially available and should certainly be used. It is believed, however, that the lesson plans and equipment designed to be used together and readily available will encourage the teaching of science in the elementary grades.

A meeting was held with the teachers of the school in which the lesson plans and kit were placed. The purpose of these devices was explained and the science equipment was demonstrated. The teachers planned to use these materials not only with the idea of teaching science but with a view to improving and expanding the content.

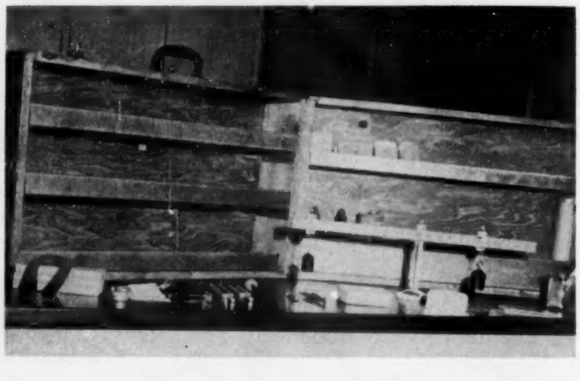
From the writer's experiences it would seem that with the right approach, senior high school science teachers can do a great deal to aid science in the elementary grades when the problem is attacked with an air of mutual effort and cooperation between teachers at the senior high and elementary levels.

The Adult Level

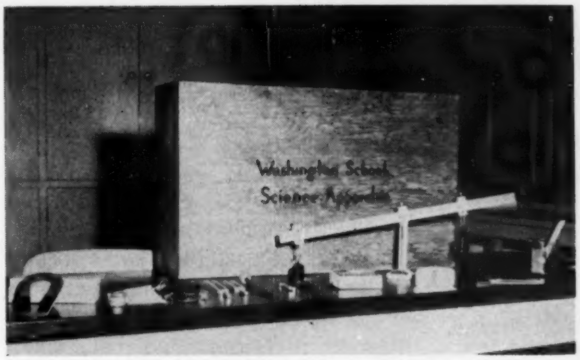
In science education at the adult level two things must be demonstrated before interest will be aroused. They are need and application.

The opportunity to extend science education to an area in which adults would be interested came about in the following manner. An invitation was extended to the writer to attend the Minnesota

Kit assembled by physics teacher of Mankato, Minnesota High School.



[1] The public school system, District 71, of Mankato, Minnesota, and surrounding areas, consists of one high school, three junior high schools, and six elementary schools.



Kit made by vocational department of high school for Washington Elementary school.

Department of Civil Defense Radiological Instructors' School for a three-day training period.

Upon returning from this school a letter was sent to the local civil defense director with the offer of cooperation in any way he deemed necessary. It was his desire that all the police and fire department personnel (56 men in all) be trained in the use of radiological instruments and their application to radiological monitoring and surveying.

Since that time three ten-hour courses have been completed during vacation and evening periods. The instructor had in custody sufficient Geiger counters, survey meters, dosimeters, chargers, and radioactive sources to make the course realistic.

Included in the course were instrument familiarization, basic vocabulary, instrument calibration, graphical methods of computing radiation dose and dose rate, hazards of a nuclear blast, radiological monitoring techniques, and talks by local and area civil defense officials. Handout material containing the above was prepared and distributed to all persons participating.

Police and fire department personnel are well aware of how they will be affected by a radiological hazard. They will be called upon to use techniques learned in the classroom and during exercises. This produced interested classes that are eager for future refresher training periods because they see the need for this type of operation and realize how they will be involved.

Future plans include training of the local Civil Air Patrol Squadron and a civilian monitoring team unit.

As a final statement it can safely be said that if a high school science teacher desires to expand into other levels of science education, there are two minimum requirements: one, the exercise of imagination to produce ideas for ways to expand: two, expenditure of energy and time to carry out the ideas.

Teaching the Average Student

By PAUL WESTMEYER

Instructor in Education, University of Illinois, Urbana

HOW the old pendulum does swing! There was a time, not too long ago, when we taught the average student. The theory was that there were so many more of them than of either the superior ones or those of lower intelligence that the best compromise was to teach the average students and hope that the rest would not be too bored, or snowed under completely. What a nice easy-going practice —but then this was in the days (Have they really left us yet?) when the whole class had to be kept together and taught the same things.

This applecart was upset by the people who came along and insistently told us that the student of lower intelligence was not learning enough material to fit him for life. He must be given special attention. He couldn't be expected to absorb enough of the average material in an average class. What he really needed was some classes in which he did not have to use his brains very much, but could work with his hands. He needed a course in auto mechanics, or carpentry, or building a house, or a lot of other things which have now become established in many of our public schools.

In science we gave him survey courses which just skimmed the surface of many topics and spent considerable time talking about science, but never getting into science. (For this we got a lot of criticism from those who advocated a return to the "good old days" when, by golly, the kids learned scientific facts or else; none of this coddling and spoon-feeding, pound it into him, tell him again and again, make him repeat it until it has soaked in.)

In the face of such criticism we had just established many of these survey courses and were branching out into broad fields courses where the survey was not even of a particular science but of several areas, or even of a combination such as science and English or science and social studies. Then along came some people who said that we were doing everything backwards; that what we really ought to be concerned with in science was not the below-average student (he would never become a scientist anyway) but the superior student who might eventually become a scientist and who at the present rate was being bored out of science courses before he even reached the high school grades. Now, said these people, let's keep the survey courses for the poorer students; an acquaintance with science may be obtained from them and they are easy and hence are OK. But let's establish some special courses in which we can challenge these superior kids who are not taking our science courses. Let's get back to real intellectual study and make them use their brains. Let's make scientists out of them.

So we did; we established special courses for the gifted students in science, we challenged them; we are making more of them into scientists than ever before (at least we think we are).

But now what do we do with the average student? There are still many of them in the 90 to 110 IQ range. It would seem, by implication from many present research studies and by implication from the way present science courses are taught, that these students are the ones to whom we lecture. They are too smart to be spoon-fed in a survey course and they are too dumb to be challenged in a special course, so we lecture them, we tell them about science and expect them to absorb. It looks as though we have been pushed into a three-track system of science education.

Is this really desirable? There is no evidence to show that the learning process is any different in a superior brain than it is in one exhibiting a low I.Q. Modern psychological theories all agree that new learnings are based upon prior learnings *necessarily*, and that learning is a process of assimilating new material and incorporating it into a reorganization of what was already there. Obviously there are great differences in the rate of assimilation and the nature of reorganization and the depth of insight but not in the nature of the learning process. Why then must students of different intelligence levels be taught in different ways? Isn't what they really need, a difference in level and difficulty of material and in speed of presentation?

Perhaps the trouble lies in the popular concept of a teacher as one who informs. Thus, since we have done away with informing the superior students in favor of letting them investigate problems on their own and since we have given up trying to inform on a very high level the poorer students, we must inform the average students or we are not performing our duties.

There are some studies to show that this may not be all wrong, that the average student is the one least benefited by "modern methods," such as group

study, directed discovery, inductive procedures, and others. Is this perhaps because he *is* average? In classes where experiments have been done the material was usually directed at stimulating the students, usually the upper level students. Now if the superior students were stimulated and performed well and the lower level students were so far out of touch with what was going on that they learned, if anything, merely from the social contacts and perhaps some habits, the average students, fitting neither category, were left cold. They could not quite comprehend what was stimulating the gifted nor were they so far out of touch that they were not bothered by it, so they struggled along trying their best but not accomplishing much.

The whole point is this: let's get back to teaching to the average student *but* remember that our main concern is not in keeping the class together but in encouraging the individual development of each student at the rate of speed which is uniquely his. Let's change the concept of a teacher from one who informs to one who leads, guides, or even pushes as the occasion may warrant, individual students along their individual best lines of learning.

Preparation

How would one run a class along these lines? The first point is that there would be a "main line" of subject matter development which might or might not correspond to present textbooks. This would be basically aimed at the average student but would not be taught primarily by lecture. It would be presented in a variety of ways including demonstration, group work, panels, and laboratory experiments. Second, the way would always be left open for a student who was "ahead" to move off in some different direction. Third, time would be provided during which the slower students could be given extra help. Furthermore, not all students would be expected to perform at the same level of competence. Most important, there would constantly be challenges and expression of ideas and a general questioning attitude which might lead the students off the "beaten path" into investigations of their own. The teacher would be careful to level the challenges at both the average and the lower level students as well as at the gifted. Anytime when a student indicated a willingness to experiment on his own, no matter how simple or how difficult the experiment, he would be encouraged to go ahead.

If this plan were really followed the teacher would soon find his class going off in just about as many directions as there are students in it. It would have changed from a class which remained together through thick and thin into a true laboratory group where some students might be cooperating on a problem but where basically each is concerned with his own investigation. But since the basic structure was a line of subject matter the problems being investigated would still be of common concern to some extent and sharing findings would be very appropriate. In other words, the students would still be learning the same basic materials as they would in a conventional course but they would be learning them in a more practical and scientific way.

It is here, of course, that the main objection to such a method arises. When the class has gone off in sixteen different directions where does the teacher go? Isn't his work immensely increased by having to prepare in so many differnet areas at once? The answer is "why prepare? Why worry about keeping up with (or ahead of) the several groups of students?" It is the one who does the work that does the learning, hence the students should do the work. Do not hesitate to say, "I don't know." Do, however, be prepared to suggest references or to say in some cases, "I will be glad to help you find out." For after all some of the problems that will arise will be beyond the ability of the students.

Science Fiction in the Elementary School

By ALAN L. DODD

Principal, Four Corners School, Silver Spring, Maryland

TODAY'S children are being bombarded by all the means of mass communication with an endless barrage of science fiction. Television, newspapers, comic books, children's magazines, and even the often forgotten medium of radio are capitalizing on the current scientific emphasis to appeal to young readers and listeners.

The bulk of the science fiction centers around space and space travel. As in actuality we move nearer to the realization of space travel, these communication mediums are already taking children into outer space by way of the child's imagination. Even the once dead and forgotten Buck Rogers has been reincarnated.

Most educators would agree they would prefer that elementary school children read material on a higher level and also watch more worthwhile television programs. However, as merely preferring this will cause no significant change in children's behavior, what use can be made of science fiction by the elementary school teacher as she teaches science to her pupils? In considering this problem let us look at two examples of how science fiction can be used at the elementary level.

Miss Jones' fifth-grade students had been working on a unit in astronomy and were quite interested in doing some activities dealing with space travel. In discussions that followed several children shared the ideas they had read in science fiction books and had seen on television. The class decided they would like to prepare an exhibit dealing with space travel. The students worked diligently preparing models of space ships, space suits and helmets, and examples of life on other planets. Most of their conceptions of such things were gained from the fictional materials that they read and saw on their TV screens. A great deal of time was spent in reproducing the detail of these various space gadgets as the children interpreted them. Their imaginations ran wild and an awesome display of paraphernalia resulted.

Mrs. Brown's fifth graders also had studied a unit in astronomy and exhibited a similar interest in space. Their teacher encouraged them to share the fictional material that was readily available on this fascinating subject. After several of the children had presented material, Mrs. Brown raised this question. How much of what has been presented is actually based on facts that can be verified. There were differing opinions as to how much of what authors incorporated into their fictional space stories was fact. Opinion ran from Billy who said, "It must all be true because I've seen it on TV" to Mary who was sure these were merely a result of the author's vivid imagination.

Mrs. Brown suggested that they take some of the ideas presented in the books and test them by consulting other sources. This the children did using reference books, scientific journals, and resource people as they sought to separate the truth from fiction and the possible from the impossible.

What values were the result of these two pieces of work labeled elementary school science? Certainly both experiences drew upon children's interest as a motivating force. Both probably kept a good part of the class interested and engaged in some type of activity. Both experiences were probably exciting enough for the children involved to remember some of the activities.

However, it would seem that the second group engaged in an experience much more likely to contribute to the realization of some important goals of the elementary school science program. These children had the opportunity and were encouraged to look critically at science fiction and either verify or reject the ideas presented. They were encouraged to employ sound research techniques on their level of understanding as they went about the job of finding out how far scientists have really gone in their plans for traveling into outer space. In sharing their ideas with one another they were able to engage in the give and take that usually helps children arrive at sound conclusions. A great deal of time can be spent constructing a space helmet out of a cardboard box without the child gaining much as far as science is concerned. This is not to say that there is no place in the elementary science program for activity. We must be careful not to lose sight of the reasons that we teach science in the elementary school.

It would seem that the latter approach to science fiction as it affects elementary school children is the more sound. That is, teachers can utilize science fiction's motivational values and at the same time help children intelligently interpret it in terms of scientific truths.

US NAVY PHOTO

Measuring engine for moon plates taken by dualrate moon position camera

IGY . . . from page 437

Gravity

To gain a clearer understanding of the structure of the earth, and to determine geographic positions more precisely, we need gravity measurements that are more extensive.

The oceans which cover 70 per cent of our planet presented a significant gap in pre-IGY gravity coverage. The difficulty was that wave motions disturbed the instruments, so they could be used only in submarines submerged to quiet depths. Just in time for IGY, a new method which made possible the first successful gravity measurements on the surface of the open sea was developed by Anton Graf of Munich. The Graf instrument, which consists essentially of a highly damped pendulum, was immediately mounted on a stabilized platform aboard a vessel made available by the US Navy to Lamont Geological Observatory. It has been obtaining data much more rapidly than is possible with submarines, and in a form that can be computed in a fraction of the time required.

Longitude and Latitude

Data obtained by newly-developed moon position cameras, established under the US-IGY program at 20 locations around the world, are being processed at the Naval Observatory in Washington, where the equipment was devised by Dr. William Markowitz. These observations will make it possible to locate the earth's land masses with an accuracy of 100 feet, where today map errors of as much as a mile have been discovered. Improved knowledge of the moon's orbit, and an improved standard of astronomical time are also expected to result.

Bench marks for future answers to the question "Do the continents drift?" are being obtained during IGY with Danjon impersonal astrolabes. Where the moon cameras permit calculation of absolute location, the astrolabes enable us to find the position of two places in relation to each other, with an error of less than two feet.

The End Product

The vast quantities of data obtained by IGY researchers—ten tons came back to the U.S. from one season's work in Antarctica—flow into three World Data Centers. One is in the United States, one in the USSR, and one serves Western Europe, Australia and Japan. Here they are copied, catalogued and indexed, and stored. Existing research institutions specializing in the various disciplines will analyze the data. Provision has been made under IGY for interdisciplinary projects, to use the findings in certain areas in several scientific fields as a source of new insights.

It will however require as much as ten years of research and evaluation before the full benefits of IGY investigations will be known.

Solving Problems by the Mole Method

By FRANK J. GOMBA

Assistant Professor, U. S. Naval Academy, Annapolis, Maryland

MANY OF US, as chemistry teachers, speak of teaching for "understanding" of the subject, while we may not practice what we preach. One segment of the course, that of problems involving equations, can be presented in a manner that will demand more than usual understanding of the topic involved. The presentation is by the mole method. It appears that we have grossly mistreated this topic with the insistence of the so-called "proportion method" for solving weight-weight and weight-volume problems. It seems that there has been enough of "this is to that, as that is to this."

A "balanced" equation, if understood properly, can tell us many things, especially the mole relationships that exist among the substances involved in the chemical reaction. Examining the equation,

$$2HgO \rightarrow 2Hg + O_2$$

we see that for every two moles of mercuric oxide decomposed, we will form two moles of mercury and one mole of oxygen. And further, we can show that no matter how many moles or fractions of a mole of mercuric oxide are used, we will always get the same number of moles and fractions of a mole of mercury as we used of mercuric oxide; and one-half the number of moles of mercuric oxide used will be the number of moles of oxygen evolved.

Now, let us take a sample weight-weight problem: How many grams of oxygen will be evolved from the decomposition of 40 grams of mercuric oxide?

GIVEN the atomic weights: Hg, 201; O, 16.

Solution: Each mole of mercuric oxide weighs 217 grams. If we knew how many moles of mercuric oxide we used, we could easily find the number of moles of oxygen formed—since the number of moles of oxygen will always be one-half the number of moles of mercuric oxide decomposed. We know the number of grams of mercuric oxide used and we know the number of grams of mercuric oxide per mole of mercuric oxide; thus we can then determine the number of moles of mercuric oxide represented by 40 grams of mercuric oxide. (Note the use of dimensional analysis.)

$$\frac{40 \text{ g HgO}}{217 \text{ g HgO/mole}} = 0.185 \text{ mole HgO}$$

Therefore, the number of moles of oxygen formed will be one-half this number of moles, or

$$0.185 \text{ mole HgO} \times \frac{1 \text{ mole } O_2}{2 \text{ moles HgO}} = 0.093 \text{ mole } O_2$$

Quickly calculating the number of grams of oxygen per mole of oxygen, namely 32 grams, and knowing the number of moles of oxygen, we can then find the number of grams of oxygen represented by this number of moles.

$$\frac{32 \text{ g } O_2}{1 \text{ mole } O_2} \times 0.093 \text{ mole } O_2 = 2.94 \text{ g } O_2 \text{ evolved}$$

We can set this up as follows for slide rule calculation:

$$\underbrace{40 \text{ g HgO} \times \frac{1 \text{ mole HgO}}{217 \text{ g HgO}}}_{\text{Gives the number of moles of HgO}} \times \underbrace{\frac{1 \text{ mole } O_2}{2 \text{ moles HgO}}}_{\text{Mole relationship from the equation}} \times \underbrace{\frac{32 \text{ g } O_2}{1 \text{ mole } O_2}}_{\text{To change moles of oxygen to grams}} = 2.94 \text{ g } O_2$$

If we wanted to know the number of grams of mercury formed, instead of the number of grams of oxygen formed, we would reason as follows:

The equation shows us that for every two moles of mercuric oxide decomposed, we will get two moles of mercury; or, if we know the number of moles of mercuric oxide used, we will form the same number of moles of mercury. Then, since there are 201 grams of mercury per mole of mercury, we can easily get our answer:

$$40 \text{ g HgO} \times \frac{1 \text{ mole HgO}}{217 \text{ g HgO}} \times \frac{2 \text{ moles Hg}}{2 \text{ moles HgO}} \times \frac{201 \text{ g Hg}}{1 \text{ mole Hg}} = 37 \text{ g Hg}$$

(This also shows why HgO is nearly as expensive as Hg.)

Should the problem be to find the number of liters of oxygen evolved, at STP, instead of the number of grams evolved, we need only to change one step in our calculations. We know that a

mole of any gas, at STP, will occupy 22.4 liters. So, if we know the number of moles of oxygen formed, the number of liters would then become no problem. Set up the problem as follows:

$$40\text{ g HgO} \times \frac{1\text{ mole HgO}}{217\text{ g HgO}} \times \frac{1\text{ mole }O_2}{2\text{ moles HgO}} \times \frac{22.4\text{ l(STP)}}{1\text{ mole }O_2} = 2.06\text{ l }O_2\text{(STP)}$$

Gas law corrections can be incorporated at this time to make the problem more conclusive.

We can summarize with the following steps:

1. Complete and "balance" the chemical equation, if necessary, used in the problem.
2. Note the mole relationships of the substances involved. (The coefficients tell the story, if correctly written.)
3. Determine the number of moles represented by the weight of the given substance.
4. Relate this number of moles of the given substance to the moles of the "unknown," to find the number of moles of the "unknown."
5. Determine the number of grams of the "unknown" in one mole of the "unknown."
6. Change the number of moles to the desired number of grams; or, change the number of moles to the desired number of liters, at STP.

Announcing Apparatus Competition

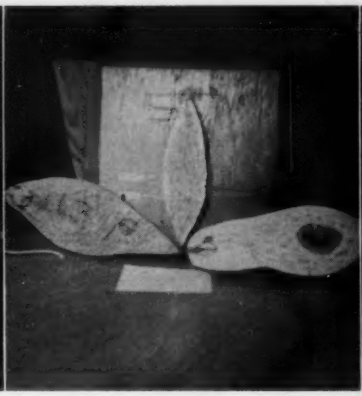
The Committee on Apparatus for Educational Institutions will conduct a competition supported by a grant from the W. M. Welch Scientific Company, for new apparatus for the teaching of college physics.

Cash award prizes up to $500 will be made for new pieces of physics apparatus, which as judged by the Committee, contribute to the advance of teaching in college physics. Two categories of the competition include (1) equipment used in demonstration lectures in introductory college physics, and (2) equipment used in the introductory college physics laboratory. Apparatus entered in the competition will be exhibited and judged at the Annual Meeting of the American Association of Physics Teachers, January 28 to 31, 1959, at the Hotel New Yorker, New York City.

For information write to AAPT Committee on Apparatus, 335 East 45th Street, New York 17, N. Y.

Paramecium
(Plastic clay mixture)

A Hand
(Wood)



Euglena
(Plaster)

Digestive System
(Modeling Clay)

3-D Models for Every Classroom

By C. A. R. JOHNSON

Glenbard High School, Glen Ellyn, Illinois

THIS ARTICLE DEMONSTRATES that functional teaching models can be made by biology students from economical materials—specifically plaster, plain plastic, plastic clay, and wood. These models enable the small high school, or any high school with limited funds for biology, to establish in a short period of time a reference display shelf of models which are functional and beneficial as teaching aids.

The use of models in classroom instruction is not a new idea in biology. But the idea of obtaining these models *from the minds and the hands of students* is one which compels attention. If these models can be obtained at a low cost, well within the means of an individual student or a group of a few students, it appears that every biology class could make highly useful models which could be kept for school use and display. Thus a class could pass to each succeeding class the results of its own study and initiative.

Multiple Values of Model Making

Several kinds of values are attached to these instructional models. The figure or model shows to the casual observer the graphic features of the subject at hand; also, it has a vivid history of student activity in its preparation. Of necessity, the student has used many facilities and techniques such as the microscope, reference books, dissection, ruler, hand lens, and other aids, supplemented by conferences with the teacher, before he finally completed the model. The model is the graphic, three-dimensional expression of the facts of his investigation. The student has had to relate size, shape, and conformation as well as to display a correct relationship of parts.

There is no one easy way to measure or evaluate the learnings that students gain from constructing models. In our experience, the following list of evaluation methods have been found to be useful.

(1) Examination of the finished model.

(2) Simple bibliography of material read and illustrations observed during the model-making process.

(3) Photos, measurements, sketches in an anatomical model.

(4) Write-ups of the model describing its use or its functional behavior or structural features.

(5) Completion of a dissection of the actual specimen from which a model was to be made; e.g., thyroid gland observed in a rat.

(6) Model made from dissection only using very little reference materials or photographs; e.g., model of flower parts.

This report was an entry in the 1957-58 STAR (Science Teacher Achievement Recognition) awards program conducted by NSTA, sponsored by the National Cancer Institute, U. S. Public Health Service.

(7) Student requested to explain his model to the class and describe its construction, function, or anatomy and be prepared to answer questions.

(8) Teacher-student conference relating to the model.

Uses

When a certain topic appears and you are equipped with a model pertaining to it, it is an easy matter for it to be brought before the class. The features shown by the model are plainly seen. The model can then be placed on the demonstration table in the room so that the class members may have closer access to it. These displays serve to generate questions and responses from students. Models serve also to stimulate the casual visitor. When a person comes into the biology room and finds something he can study by himself, he very likely will return at a later date to see additional displays or get information.

Making Plaster Models

One of the outstanding features of models from plaster is economy. A twenty-five cent sack of plaster obtained from the hardware store provides abundant amount of material for making models.

Conventional mixing instructions are frequently printed on the bag or container in which the powder is purchased. Fundamentally, the procedures involve mixing the powder with and allowing it to stand for a period of time. From time to time the mixture is stirred to prevent lumping. The smooth mixture is then poured into a mold or into an oiled or waxed paper box of whatever size or configuration is called for by the type of model being made. Larger models require stronger forms or molds for holding the heavy mass of plaster.

Soon after pouring the plaster will begin to set and the model is then ready for immediate tooling and shaping. Appropriate tools are employed (knife edge, broad blade, scraper, and others) to oultine the general features of the model. Careful carving and the removal of excess plaster is now accomplished. This pliable mass is pressed, carved, packed, raised, or curved into its proper shape. During these processes, water may be added to delay settling or hardening of the mass.

When the precise stage and degree of configuration is reached, the model is set aside and allowed to harden. After perhaps a day or two the model is painted with conventional indoor house paint of various colors to accentuate the carving and sculpturing, enabling a clear differentiation of systems

(Continued on page 480)

Phillips . . . from page 447

Is this force always an "unbalanced" force? And what is the meaning of the phrase, "When acting on objects"? Does the "force of gravity" have some independent existence, so that it is there, even when "not acting on objects?" The Law of Gravitation describes the force of attraction between two masses; it does not permit any conclusions about a situation involving an interaction between one mass and nothing.

Because there often seems to be confusion about the distinction between mass and weight, one not infrequently finds a section or a paragraph devoted to the confusion—and not always does it serve to provide any real clarification. One text says this:

> "In most cases the mass of an object is measured by weighing the object in scales. We shall see later on in the chapter that the weight measured in this way is not exactly the same as the mass. But for practical purposes we can consider the mass to be the same as the weight."

And later on, in discussing "Force vs Mass":

> ". . . use an equal arm balance and standard set of masses (commonly called a set of weights), and the true mass of the object is always equal to the mass it balances, no matter what the force of gravity may be."

Now one could defend this argument, sentence by sentence, and, *provided it were understood* that what is meant in the earlier sentences is that "the *number* of units of weight is not exactly equal to the *number* of units of mass, but for practical purposes we may consider these *numbers* to be equal," he could insist that each statement is true. But even then the matter would be far from clear. What the student will infer from the discussion (and what more than a few high school teachers infer from the discussion) is that since the gravitational force on an object changes slightly from point to point on the earth, this somehow makes the mass and the weight slightly different, but to say that they are the same is not *conceptually* wrong, it's just slightly inaccurate. The same idea is obtained from another text, in which one finds similar statements. Mass and weight having been mentioned, these words follow:

> "To distinguish between them, remember that the weight of a body can vary, but its mass cannot."

And then there is a footnote saying that the mass can increase if the velocity is exceedingly great. Later on, the change in weight of a body trans-

ferred from New York to Denver having been described (about 2 pounds in a ton of sugar), the statement is made:

> "Usually such small changes do not bother us. However, physicists want their science to be very accurate, so they use mass more than weight."

One does not distinguish between mass and weight by remembering that one changes and the other does not, any more than one distinguishes between the age and the sex of an individual by remembering that the age changes but the sex does not—and a footnote saying that if the object is an oyster, or an exceedingly skillful surgeon is available, the sex can change, does not help to clarify matters. The second statement again really says that the distinction between mass and weight is merely a question of significant figures, and not at all one of a difference in the two concepts, and the physicist is just a snob and a piddling quibbler when he insists on using mass instead of weight. Really, the whole difficulty arises from failure to distinguish between the *name* of a unit and the *unit* itself. One book makes no bones about it whatsoever:

> "Unfortunately both mass and weight are measured in the same units. . . . This fact adds to the difficulty of distinguishing between mass, weight, and force."

And of course this is just plain wrong. Unfortunately, some units of mass happen to have been given the *same name* as some units of weight, and this leads to a bit of confusion—even among writers of textbooks. Mass and weight are *not* measured in the same units. To say that they are makes no more sense than to say that "time" and "angle" are measured in the same units, just because units named "minute" happen to be in use for both.

Along with the discussions of the second law, one finds a number of inaccurate or poorly worded statements, a few examples of which are cited below:

> "In a baseball game the infielder who catches a hard ball wants to slow down the momentum of the ball so it does not hit his hand with full force."

Just what would "full force" mean? Say the ball has a mass m, and is moving with a velocity v, so it has a momentum mv (this, incidentally, is the product of its mass *and* its velocity; not, as several texts say, the product of its mass *times* its velocity), and this is equal to the product of the stopping force F and the stopping time t. That is, $Ft = mv$, so, for a given momentum, the shorter the stopping time the greater the force required. But *full force* is what? And does one really "slow down" the *momentum?*

> "A ferry boat in docking moves very slowly, but a foot caught between the slowly moving boat and the dock would be crushed by the momentum of the boat."

Does momentum crush, or is it the force that would be exerted on the foot that will do the crushing?

> "If a ball thrown with a given force moves with a velocity of 50 feet per second, the force must be doubled to make the ball move with a velocity of 100 feet per second."

This is true only if the accelerating *time* is the same in both cases. The higher velocity could be attained equally well by applying the same force for double the time, or by any combination of F and t whose product is doubled.

> "Place a book on a sheet of paper. Jerk the paper away and the book will remain behind. The small force of friction cannot overcome the inertia of the book."

Actually, the clue to the apparent immobility of the book is not in the small force of friction, which would undoubtedly be sufficient to make the book move along with the paper if the paper were moved more slowly, but in the "jerk" which results in the paper being pulled out so rapidly that, despite the fact that the book is given an acceleration by the "small" force of friction, the time is too short to permit the book to attain an appreciable velocity. Once again, $mv = Ft$, and v is small, *not* because F is small, but because *t* is small. Any unbalanced force, however small, can produce acceleration of any mass, however large; the velocity the mass attains, however, depends jointly on the acceleration and *the time the acceleration is maintained.* And just what does one mean by "overcoming" inertia?

> "The acceleration of a body starting from rest is the rate at which the speed of the body changes."

Granting that perhaps in a high school physics course the word "rate" will always be taken to mean "time rate," and overlooking the fact that acceleration is the time rate of change of velocity rather than of speed, one still wonders what the words "starting from rest" are doing here. Isn't this what one means by acceleration, whether the body is initially at rest or in motion?

This article will be continued as Part II in the February issue of TST covering Newton's Third Law.

A Demonstration Lens

By ROLAND O. SPRECHER

Central Senior High School, Madison, Wisconsin

This report was an entry in the 1957-58 STAR (Science Teacher Achievement Recognition) awards program conducted by NSTA, sponsored by the National Cancer Institute, U.S. Public Health Service.

A MAJOR objective in science teaching is the development of student ability to solve specific problem situations through the application of underlying principles. As with most goals, one must teach specifically toward this objective if it is to be attained.

Many students tend to study related situations as though they were isolated phenomena, learning the facts in each case by rote rather than by reasoning from underlying principles. If they can be taught to reverse this tendency, definite progress will have been made toward this objective, and they will derive greater satisfaction and depth of understanding from their work. The apparatus described in this paper was conceived and built with this objective in mind.

The Problem

The specific teaching problem that led to the development of this apparatus was that of developing a thorough comprehension of the relationship between the object distance (D_o) and the image distance (D_i) in various cases of image formation by a positive lens.

In studying optics, students learn the laws of refraction and the lens formula, and they work problems involving D_o and D_i. Subsequently,

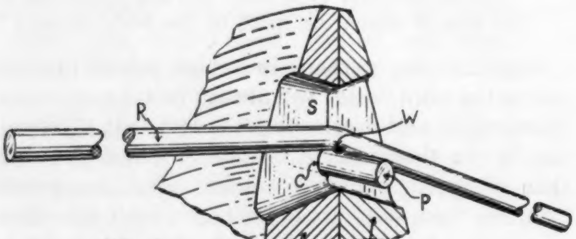


FIG. 1

however, many do not truly understand these distance relationships in the basic "six cases" of image formation [i.e., with the object located (1) between the principal focus, f, and the lens; (2) at f; (3) between f and 2f; (4) at 2f; (5) at a measurable distance beyond 2f; or (6) at infinity]. They resort to memorizing the charts and diagrams of these cases, as found in the textbook.

The problem, then, was how to help students arrive at the "six cases" by reason not rote.

Solution: A Model Lens

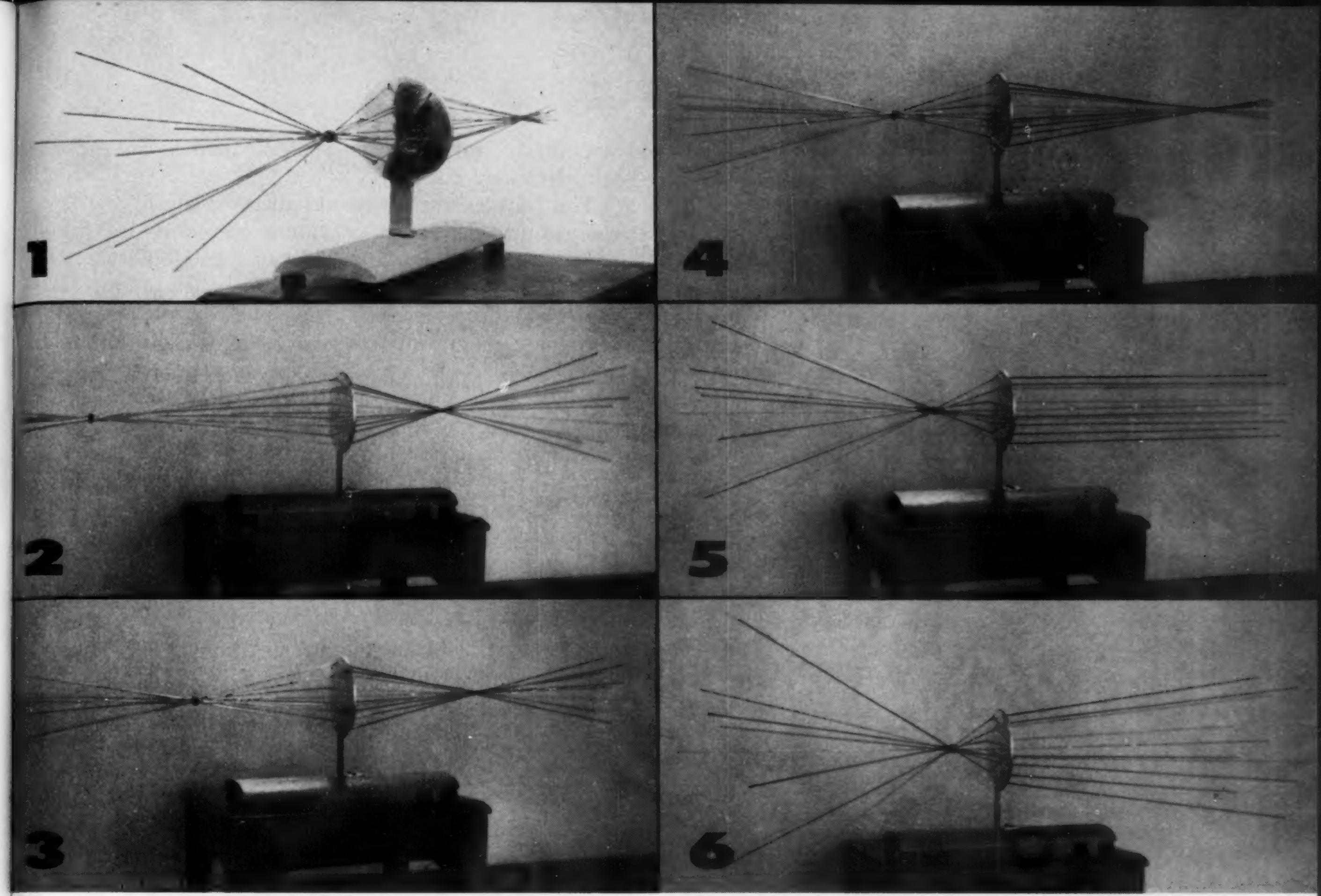
As a working hypothesis it was assumed that the connotations of the refraction laws they had "learned" must have escaped these students, for the "six cases" are a direct result of the operation of those laws. It followed from this hypothesis that conventional methods and devices for teaching refraction principles must be inadequate. Textbook and chalk-board diagrams, optical disks, and even actual lenses are static with respect to the "six cases." They cannot clearly demonstrate transitional phenomena from case to case.

What was needed was a device which would visualize light rays and demonstrate the transition process in a fashion that would make refraction principles a part of the students' working knowledge.

The apparatus represents each light ray as being analagous to a lever, bent at its centrally-located fulcrum within the lens so as to represent refraction of the ray. (The "thin lens" proposition permits the use of a single bend.) One such bent lever R is shown in Figure 1, which is a radial section through the slot S, through which the lever passes, near the edge of the lens L, L'. The lever (hereafter referred to as a "wire ray") is made of 1/16″ steel wire, and has a short piece of the same wire spot-welded to it at the fulcrum W to act as the pivot P.

Figure 2 shows, schematically, four such wire rays R passing through the slots S in the lens L, L′, with their pivots P mounted in bearings within the lens, which is shown in vertical section. The straight wire A represents the principal axis, and has the f and 2f points marked on it with paint. A rubber focusing ring F holds all of the rays in a bundle around the axis, as shown. This ring, free to slide along the axis, may represent either an object point or an image point, as desired.

Manually sliding the focusing ring to and fro along the axis causes all wire rays to rotate on their pivots so that their point of convergence I will occur at the proper distance from the oppo-



1. Features one surface of lens; 2. Ray pattern with focus ring beyond 2f; 3. Ray pattern with focus ring at 2f; 4. Ray pattern with focus ring between f and 2f; 5. Ray pattern with focus ring at f; 6. Ray pattern with focus ring between f and lens.

site side of the lens. All of the "six cases" can be shown by sliding the ring to the proper location for either object or image, and the lever analogy involved in the process makes the D_o to D_i relationship quite logical—even obvious—to students.

It will be apparent that the fixed refraction angle of the wire rays is not mathematically precise for all angles of incidence. Consequently, the model is not adaptable to quantitative experiments, but that is not its purpose. Rather, it serves to help students develop that insight into lens behavior without which subsequent quantitative experiments cannot be truly meaningful. The deviation is too small to be noticeable, however, and students are given to understand that it exists as a necessary consequence of the mechanical analogy.

Construction Details

The following details will amplify the above general description:

The lens is made of aluminum, which is easily machined, does not corrode, and takes a high polish so as to stimulate a lens surface. It consists of the two plano-convex halves, L and L′, cemented together to form a double convex lens 4½″ in diameter and ¾″ thick at the center. The pivots P are held in place, sandwich-wise, between the lens halves, where they fit into bearings formed by mating cylindrical grooves C, as shown in Figure 1.

The slots S, through which the wire rays pass, must be slightly wider than the diameter of the wire rays, and long enough (⅜″) to allow free movement of the wires. Figure 3 shows one surface of the lens with the wire rays removed; note that the ray slots S are arranged in two concentric circles around the axis A so as to demonstrate the difference in the degree of refraction at different distances from the axis.

The wire rays R, 36″ long, are first bent to approximately their correct angles and spot-welded to their pivots, then inserted through their slots in one lens half L. The other lens half L′ is then slipped over the wires and cemented to its mate with a "contact" type cement.

A strip of ⅛″ sheet aluminum, 1″ wide x 6″ long serves as a support U for the lens. One end

of it is cemented into a socket milled into the bottom edge of the lens halves before assembly, and the other end is bent at 90° and screwed to the wood base B.

An appropriate distance (4½″ in this instance) is chosen for the focal length, and the principal foci f,f are marked on the axis A with white paint. The conjugate foci 2f,2f should then be double this distance, or 9″ from the lens, but they were extended to 9¼″ to correct for the discrepancy resulting from the fixed angle of refraction of each wire ray, then marked with paint.

Finally, all rays are gathered together around the axis wire at one end, and the focusing ring F is slipped over the resulting bundle. The ring must be a snug fit, but free to slide. It must also be elastic to accommodate the increasing diameter of the bundle as the wire rays converge at wider angles nearer the lens. The ring used was cut from the end of a rubber tube, and is lubricated with glycerine.

After assembly the refractive angle of each ray is given its final adjustment by sliding the focusing ring to the f mark and bending each ray at its pivot point, if needed, so that its free end emerges from the lens parallel to the principal axis.

Results

The apparatus was built nearly a year ago, but not completed until after the physics classes had concluded their study of light. Nevertheless, it was then demonstrated to them, and their reactions were revealing: At first the model was merely placed on the desk for all to see. It evoked only faint interest which soon decayed to boredom, for it was a static display showing little that they had not recently studied, and it was not pertinent to the assignment for that day. Then the focusing ring was moved to and fro along the axis, and as the wire rays dutifully responded the classroom atmosphere was electrified: "Look, they move!" "Do it again!" "Which is the image?" Apparently, the apparatus would at least be an attention-getter!

The bent-lever analogy was then explained, and the ensuing discussion consumed an entire class period. From the many questions and observations it became apparent that a number of students who had "learned" the behavior of lenses were only now truly comprehending it. It also developed that the apparatus was superior to conventional devices for demonstrating such principles as chromatic and spherical aberrations, dispersion, magnification, virtual images, conjugate foci and others, in addition to the D_o to D_i relation for which it was specifically intended.

Recently, one year later, the apparatus was used as the basic instructional device, with conventional apparatus used as supplements to it. It was constantly available during the study of refraction, and frequently was used by students and teacher alike to investigate or demonstrate a variety of phenomena. Moreover, it was apparent that logic and comprehension were replacing rote memory as the basis for solving refraction problems.

Discussion

Almost any lens phenomenon can be demonstrated with this apparatus. A few of the more prominent demonstrations will be described briefly.

One begins by removing the rubber focal ring and manipulating a single wire ray, so as to establish the "bent lever" analogy, pointing out that this is only a close, but reasonable, approximation to the true state of affairs. The ring is then replaced and moved to and fro a few times to demonstrate the general action of the model.

The principle of image formation is demonstrated by sliding the ring to any position that results in convergence of the free ends of the wire rays. One then points out that all rays originating at an object point (the rubber ring) are so bent by the lens, no matter where they penetrate it, as to meet at a common focus, which becomes

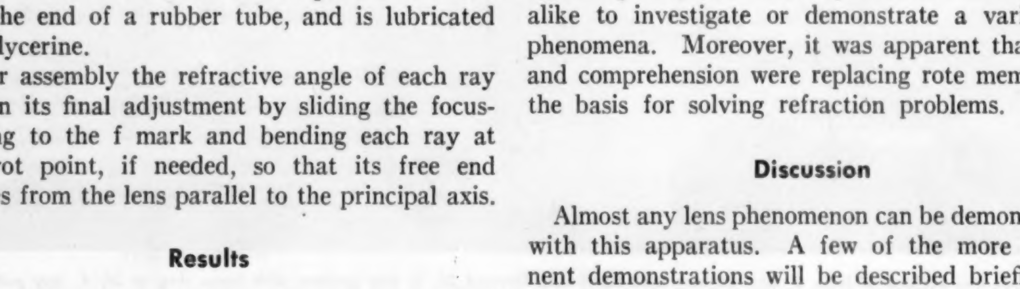


FIG. 2

an image of that point; and that, since all ray paths are "two-way streets," either of these points could be the image of an object placed at the other point. The general relationship of D_o to D_i can now be stressed while sliding the ring throughout its range.

The six basic cases of image formation are best shown by starting with the focal ring at f, whence

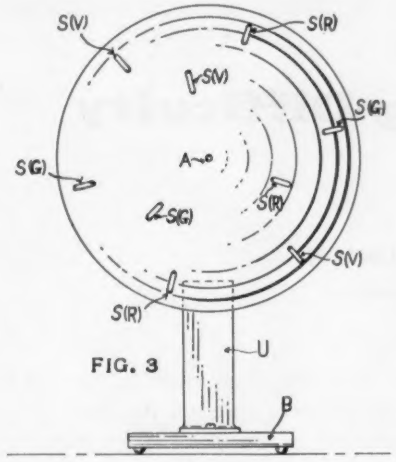


FIG. 3

the refracted rays emerge parallel to the axis (Di= infinity). By imaginary reversal of ray direction this also shows image at f for an infinitely distant object. Next the ring is moved to the 2f mark to show conjugate foci, equi-distant from the lens. The third adjustment is intermediate between the first two, between f and 2f, whence the refracted rays quite logically converge beyond 2f, again representing two opposite, conjugate cases by ray reversal. One should show that this latter pattern also results from moving the ring outward beyond its 2f point. Finally, with the ring between f and the lens the refracted rays diverge.

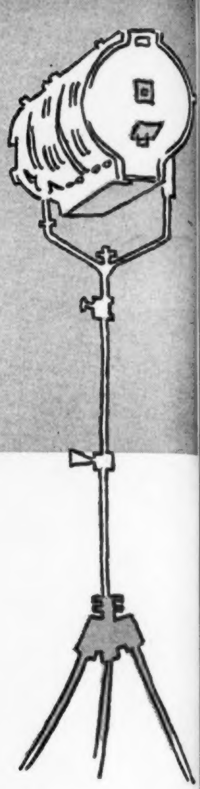
The simple microscope can be shown with the rubber ring (serving as the object) between f and the lens, the refracted rays diverging. Two 12″ pieces of straight wire are then held on the ring side of the lens, each with one end in a ray slot and in line with the refracted ray, indicating by convergence the virtual image location.

Focusing of a camera is shown with a sketch of a box camera on bristol board, which is held upright behind the lens model. Adjusting the rubber ring to various object distances will focus the wire rays either before or behind the film in the sketch, and the lens model is then moved along the desk to bring the image focus to the plane of the film.

To show dispersion and chromatic aberration, nine wire rays were used, since this is a multiple of the three primary colors of light. The rays emerging from the right side of the lens in Figure 2 are painted alternately red, green and violet. Thus there are three refracted rays of each color (their corresponding slots are labeled (R), (G) and (V) in Figure 3). For this demonstration the refractive angle of all red rays is decreased slightly by bending them at the fulcrum, and the angle of all violet rays is similarly increased. The red rays will then focus farthest from the lens, the violet rays closest to it, and the green at an intermediate point. The wire rays can be readjusted to coincidence without damage.

Although no single piece of apparatus can be considered best, or even applicable, for teaching all of the principles of refraction, image formation and dispersion, the mechanical lens model has proved itself the most versatile and effective for developing an insight into the practical operation of these principles. Properly supplemented, it serves as an excellent basic instructional device in the teaching of optics.

SPOTLIGHT on RESEARCH



Textbook and Reading Difficulty In Science Teaching

By GEORGE GREISEN MALLINSON
Western Michigan University, Kalamazoo

THE literature of science education is replete with articles that decry the textbook approach in teaching science. Yet there are facts to show that more money is spent for textbooks than for any other instructional aid. Further there is no evidence that the use of textbooks is likely to decrease. Rather, with growing school enrollments and with the inevitable increase in class size, it is likely that teachers may depend even more on textbooks than they do now. It seems reasonable therefore that efforts should be made to utilize them effectively.

Unfortunately, far too little research has been undertaken on the utilization of science textbooks. However, the studies that have been published elicit conclusions that should not be disregarded.[1]

The Value of Textbooks

Several investigators have sought to learn whether textbooks could be replaced satisfactorily in the classroom situation with other published materials. These investigators assembled various documents such as industrial, government, and trade publications that dealt with the areas taught in certain science courses. These materials were then used with groups of students whose achievements were compared with those of students using textbooks. These studies failed to show any significant advantage of one type of published material over the other in so far as student achievement was concerned. It was concluded that the time and effort required in assembling the materials to replace the textbook were not justified.

In general, these research studies seem to suggest that, other factors being equal, the textbook is a satisfactory source of the basic materials for teaching science. The time and effort expended in selecting publications to replace the textbook is probably best spent in locating materials to supplement the textbook and to provide for individual differences and interests among the students.

The Abilities of Teachers to Select Textbooks

It is obvious that a teacher or group of teachers charged with the selection of textbooks should be cognizant of the criteria for their selection. Also these persons should be able to utilize these criteria for selecting the textbooks that are most suited to their local needs. There are available at present several excellent check-lists for use in selecting science textbooks.

Most of the research findings indicate however, that few teachers are as well acquainted as they should be with the textbooks they select. Further, many do not increase their knowledge of their textbooks substantially even after they have been used for some time in their classes. Thus, neither the positive values of the textbooks are exploited nor their negative characteristics avoided.

Several studies also cast doubt on the ability of reading experts or classroom teachers to evaluate the levels of reading difficulty of textbooks of science. It has been generally assumed that "a

[1] The studies will not be documented here. The bibliography, however, can be obtained by writing the author.

good teacher" can do so. The research findings however, suggest that the estimates of "reading experts" concerning the reading difficulty of a science textbook may be expected to vary as much as two grade levels from the measurements made with formulae. The estimates of teachers may deviate as much as four grade levels. Reading formulae, however, such as the Flesch, Dale-Chall, and Lorge show great consistency when they are used for making such measurements. While most of such research on evaluation of reading difficulty has been done with materials for elementary and junior-high school science, there is every reason to assume that the findings apply also to textbooks for high-school science.

It may therefore be recommended that evaluations of the levels of reading difficulty of textbooks should be accomplished with reading formulae rather than by inspection. This would seem to be particularly desirable in view of the fact that many textbooks of science are too difficult for the students for whom they are designed.

The Reading Difficulty of Textbooks for Science

An extensive series of studies was undertaken during the past few years to evaluate the levels of reading difficulty of the textbooks designed for use in elementary, junior-high-school and high-school science courses. In most of these studies the Flesch formula was used as the measuring device. The findings of all these studies led to the following conclusions:

1. The reading levels of many textbooks in science are too advanced for the students for whom they are written.
2. The difference between the levels of reading difficulty of the easiest and the most difficult textbooks in any area of science are significant.
3. In some textbooks of science whose *average* level of reading difficulty seems satisfactory, there are passages that would be difficult for some students in grades well above those for whom the book is intended.
4. Many textbooks of science contain non-technical words that could be replaced with easier synonyms.

These findings indicate that the factors of reading difficulty cannot be ignored in selecting or using a science textbook and that students may need assistance and guidance in reading in order to utilize their textbooks most effectively.

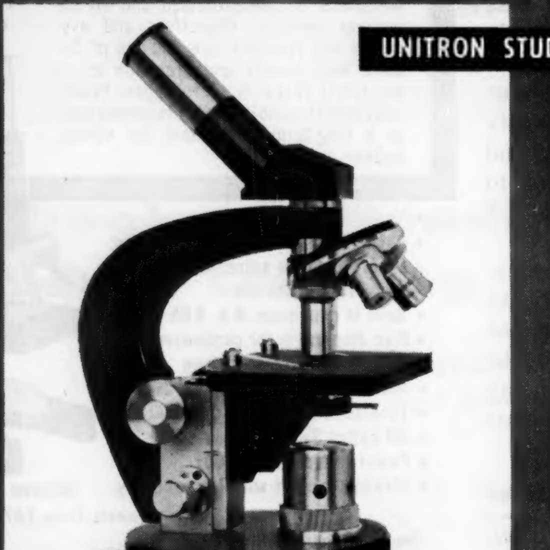
Implications for Using a Textbook

A textbook is, of course, more than a complex of words to be memorized. It consists of a pattern of illustrations, verbal explanations, questions and suggested activities. Every science educator should become intimately acquainted with the manner in which such materials are organized and the best ways to *use* them. The science textbook should be used not as a reading assignment but rather for the value its illustrations, questions, and activities can contribute to the science learnings. This means however, that critical judgment must be utilized in selecting the book rather than depending on the appeal of the salesman or the attractiveness of the cover. With such a viewpoint, the teacher of science can use the science textbook effectively. The book will not use the teacher.

Editor's Note: This continuing series of articles, which are prepared by NSTA's Committee on Research under the chairmanship of Dr. William Reiner, is provided to assist TST readers in these areas. We suggest readers submit their suggestions for articles in the spring issues by writing direct to Dr. Reiner. This particular topic is also related to the interesting discussion by Mr. Phillips on page 444, on which comments are also invited.

UNITRON student microscopes offer

UNITRON STUDENT AUTO-ILLUMINATION MICROSCOPE, MSA



The UNITRON Student Auto-Illumination Microscope, Model MSA, employs a newly designed stand in which all components and controls are within easy reach. The inclined eyepiece tube allows comfortable posture and may be turned in any optional observing direction to permit two students sitting side by side to share a single instrument. With the built-in illuminating system of the superior low-voltage type, each student is assured of the correct lighting. The transformer is conveniently housed in the microscope base itself where it contributes to the stability of the stand rather than to the clutter of the laboratory table.

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The optical performance of Model MUS at each of its magnifications is equivalent to that of expensive research models. All mechanical parts are machined to close tolerances and the stand is beautifully finished in black and chrome. Model MUS comes complete with triple revolving nosepiece and three objectives: 5X, 10X, 40X; choice of two eyepieces from: 5X, 10X, 15X; coarse focusing (accessory safety stop available); condenser with iris diaphragm; inclinable stand; planoconcave mirror; wooden cabinet and dustcover. Mechanical stage available at extra cost.

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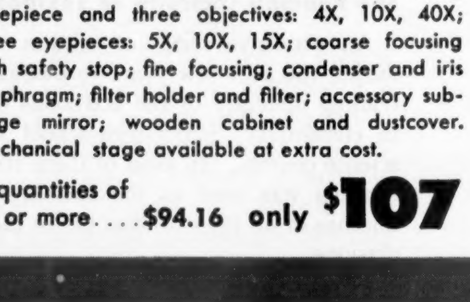


Classroom Ideas

Biology

Assignments in the Study of the Invertebrates

By SISTER M. CLARICE, O.P., San Gabriel Mission High School, California

This report was an entry in the 1957-58 STAR (Science Teacher Achievement Recognition) awards program conducted by NSTA, sponsored by the National Cancer Institute, U. S. Public Health Service.

High school biology students are at first repulsed, then curious, interested, and finally intrigued by the study of the invertebrates.

Classwork Preparatory to Laboratory Work

The actual procedure for instruction generally begins with the presentation of the subject matter in a clear, logical manner. Here the teacher follows an outline so that the students can learn to take intelligible notes—a skill which college professors expect of their student scientists.

The teacher will make use of blackboard, diagrams, charts, and, best of all, the actual specimen for her instruction. Microscopic studies and dissections of the available animals are essential aids to the mastery of the anatomy and physiology of the invertebrates. Where it is possible to obtain movies, these, too, furnish incomparable information and interest.

Work in Field and Laboratory

These devices having been utilized, the students are then ready to study the animals in their native environment. Field trips to the beach at favorable tide conditions are invaluable and necessary experiences for those near the seacoast. During such field trips several students may work together to collect representative members of one phyla; for example, the mollusca. The preservation and identification of various clams, snails, slugs, chitons, squids, octapi is a joint process and is easily and inexpensively carried out.

The cardboard lining of the lid of a mayonnaise jar is removed. Holes are made through which different lengths of string are passed. The mollusks are attached. Knots are made at the opposite end and the cardboard is glued on the inside of the lid as is shown in the diagram. The shell animals are preserved in alcohol (no shells should be stored in formalin). Finally the identification labels are placed on the outside of the jar. This final requirement of identification sends the students to supplementary books which prepares them for formal research. The biologists accompany the project with a written report of the trip.

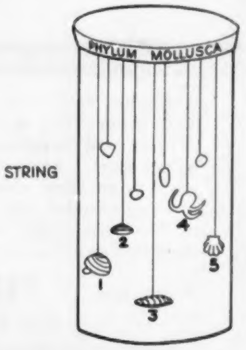


Figure A
Jar showing method of mounting marine specimen. 1. Clam; 2. Limpet; 3. Chiton; 4. Octopus; 5. Scallop

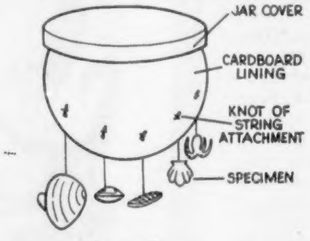


Figure B
Inner lining of jar to which invertebrates are attached.

Testing

As a part of the testing program the following procedure has proved interesting as well as challenging. Each table in the laboratory is numbered, and next to the number is placed a specimen. The students are permitted to come into the room on "D-Day" with only a numbered paper folded so

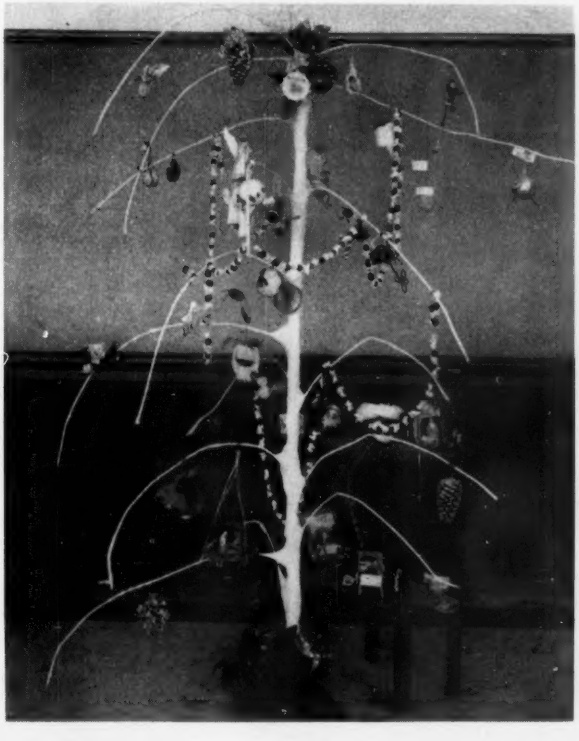
that the name of the specimen or a particular structure or organ may be named and identified according to phyla and class. As the junior biologists enter the room they are instructed to remain at their usual place and to identify the invertebrate there. At a given signal (tap of a bell) all move on to the next place. This is repeated until all the specimen have been identified.

This test, of course, merely covers the "mechanics" of the study. Thought questions covering the biological principals and generalizations constitute the essential evaluation.

A Creative Assignment

At Christmas time an assignment may be given to provide an ornament for a Biology Tree. The essential requirement for the ornament is that it is or represents a biological specimen. The accompanying photograph will give some indication of the type of ornaments which may be created. Prize contribution here is "Bugnick" (this was made before Explorer was launched). A runner-up is a peanut Santa Claus drawn in a chariot pulled by flies. All specimen must be identified.

Such a human interest assignment eases the intensive efforts of weeks of solid study, and offers a cultural, artistic and creative expression of the beauty of the invertebrate animals.



Physics

Earth's Magnetic Field

By ROBERT H. LONG, Green Mount College, Poultney, Vermont

High school physics and general science students may be interested in this experiment as it relates to some of the activities of the International Geophysical Year.

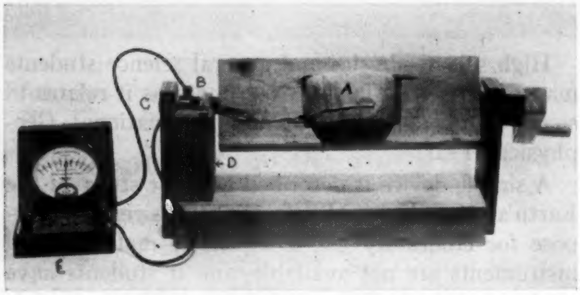
A simple device is described here for study of the Earth's magnetic field. It might answer the purpose for laboratory use if expensive materials and instruments are not available, and if students have an interest in building apparatus. The materials include: A coil of insulated wire of a few hundred turns (perhaps salvaged from an old-fashioned radio loudspeaker, or a small transformer), some copper and brass, wood, a galvanometer, and wire from the science laboratory.

The Experiment

As shown in Figure 1, the generator is made of wood, for easy construction and to eliminate possible fields. The coil (A) is mounted in a slot in a block of suitable size; this, with wooden dowels at each end for shafts, forms the armature. The current take-off is a slip-ring arrangement (B). (This gives an alternating current that produces a noticeable effect on the galvanometer for demonstrations.) The rings are made by soldering bands of copper on the shaft, and securing them with small brads. The outer ring is put on first with a wire to the coil. The inner ring is placed over several layers of friction tape, so as to properly insulate the wire going to the outer ring. The brushes are made of brass strips mounted (with clip terminals) by screws to wooden blocks set on both sides of the shaft (D). The end of the shaft, at C, is cut off, flush with the mounting support, so that the generator can be conveniently set on end. For comparative results, the armature should be rotated at a constant rate, by means of the crank. For actual operation, the galvanometer should be connected with longer pieces of wire, so that the rotating coil is away from the magnetic field of galvanometer.

In operating the generator, the axis of rotation can be placed at any selected angle and direction from an imaginary line extending from the point of operation to the zenith. However, even with this very simple apparatus, a striking difference in the fluctuation of the galvanometer will be observed

when the generator is operated with the axis of rotation in a vertical position, and then in a horizontal position. With the aid of handbook tables on magnetic inclination, students can work out explanations for positions of maximum and minimum induc-



A. Coil
B. Slipring (current take-off)
C.-D. Shaft
E. Galvanometer

tions. This very simple project may lead interested students to plan and build more sensitive units, and to make quantitative measurements of the effects of the earth's magnetic field.

Johnson . . . from page 468

or parts to be shown. After careful drying, the model is ready for mounting on a display stand and labeling of parts.

Two bits of advice at this point: (1) the paper form in which the model was made may be taken off prior to painting. This affords maximum protection of the model until it has had a good chance to harden; (2) painting the model before it is completely dry may prove troublesome.

After the model is painted, proper display methods are important. Securely fasten the model to some backing such as wood board, heavy fiber board, or other suitable material. Stands supporting this backing are used to advantage. Labels which clearly identify the parts of a model should be attached. This may be done by placing the name of the part or structure on a label, then attaching a small cord to the correct part of the model. Securing the label and cord is accomplished by dipping in glue and pressing the cord and label against the surface of the model and on the surface of the backing.

Plastic and Clay Models

Making models out of plastic and modeling clay involves many of the same techniques employed in plaster models. Individual types of plastic vary; for each type, however, specific instructions are given for mixing and handling. These materials are more expensive than plaster and probably should not be tried until students have had fruitful results with less expensive materials.

The special forms of these materials are somewhat difficult to handle and are generally employed for specific needs for a particular type of model. Useful types may be obtained from sources such as art centers, dime stores, or hobby shops. Your local dentist may give you addresses of sources of materials such as he uses to make molds and forms of mouth configurations (to make teeth.)

Making models for use in teaching and learning biology not only involves knowledge of a scientific nature; it also involves a limited but workable knowledge of art in the formation stages and in the proper painting and label work demanded in a good display. All of these qualities, when combined by a student, should make the resulting model an item of beauty which is useful in a pleasing presentation of the subject. It is thus assured of the students' attention, and it helps to utilize the gateways of both "seeing" and "feeling" as ways of learning.

NSTA Activities

Secondary Science Teaching

A pilot study of new developments in secondary school science teaching is being conducted by the staff of the National Science Teachers Association. Made possible by the financial assistance of the Shell Companies Foundation, the study will be reported in bulletin form early in the spring in order to aid those schools planning revisions in their science programs. It is expected that a more extensive study of the status of developments in science teaching will be undertaken by NSTA's Commission on Education in the Basic Sciences at a later date.

NEA Building Dedication

Formal dedication of the new NEA headquarters building will take place on February 8, 9, and 10. Dr. Frank W. Hubbard, NEA Assistant Executive Secretary for Information Services, is the general chairman of the dedication committee. A leaflet titled "Program Plans for Local Dedication Days" has been prepared by the committee and is available from NEA headquarters free on request for local units planning to arrange their own celebrations of D-Days.

The program will include several speakers and representation by NEA officers, state directors, and local units, involving discussions of basic educational problems and related programs. NSTA's Executive Secretary and a number of D. C. area guests will participate in the ceremonies and hold a special NSTA dedicatory luncheon on Monday, February 9.

Convention Notes

Miss Helen E. Hale, Chairman, and members of the 1959 convention planning committee are rapidly "plugging the gaps" and winding up details for the Atlantic City Convention. Along about the middle of January, essential information, advance registration procedure and reservation forms will be sent to all members of NSTA. *It is strongly urged that everyone who can possibly do so, should register in advance.* Because of the large attendance which is expected, registration for the convention will be a requirement for admission to all sessions. Moreover, several of the sessions will be limited in the number of participants that can be accommodated and these are expected to be filled completely through advance registrations.

In addition, there will be an exhibit of NSTA publications and services on display near the registration desk. Publications will be available for examination, or for placement of orders. An NSTA representative will be on hand to describe our services and to accept new membership applications.

All exhibit booths have already been allocated to a large variety of producers and suppliers of teaching materials for science. This exposition of science teaching items will be the largest and most varied ever offered at an NSTA convention.

STAR Program for 1960

The National Advisory Council of the National Cancer Institute, for the third successive year, has approved NSTA's proposal for advancing science teaching through the program of Science Teacher Achievement Recognition (STAR) awards. Requirements and procedures for participants are being developed by a national committee, and will be announced to NSTA members and other science teachers in January.

STAR '60, as the program will be known, includes cash awards and certificates of merit for teacher-written reports of unusual or effective techniques or procedures in the teaching of science at junior and senior high school levels. A principal objective of the program this year is to encourage teachers and practicing scientists, or other scientifically trained persons, to collaborate in planning, testing, and reporting ideas to improve the teaching of science.

The Executive Secretary of NSTA will serve as director of STAR '60 with Dr. Abraham Raskin of Hunter College, New York City, serving as secretary and editor of the brochure to be published after completion of the program.

Following announcement of the program, entry and information forms will be made available about the first of February. Closing date for submission of entries will be December 15, 1959. It is expected that the presentation of awards will be made at the 1960 National NSTA Convention in Kansas City, March 29-April 2, 1960.

FSA Activities

FSAF Sponsors

The following business-industry organizations and personnel contributing financial support to FSAF have been added to the roster of sponsors since the September listing.

Archer-Daniels-Midland Company
The Atlantic Refining Company
R. P. Dinsmore
Johnson & Johnson
Revlon Foundation, Inc.
Shell Companies Foundation, Inc.
Stauffer Chemical Company
United Aircraft Corporation

PASS Conference

On December 4-6, a conference on Providing for the Able Science Student (PASS) was held in Washington, D. C. PASS was jointly sponsored by NSTA's Future Scientists of America Foundation and the National Education Association with about twenty educators participating, all of whom are actively concerned with meeting the needs of students with greater than average ability and motivation in science in grades 7 through 12. The director of the conference and "architect" of the report to follow is Dr. Robert R. Donaldson, State University Teachers College, Plattsburg, N. Y.

The purpose of the conference was twofold: (1) to provide assistance to teachers planning programs in science for this group of students; and (2) to expand the section on science teaching of the report of the NEA Conference held last February on the Identification and Education of the Academically Talented Student in the American Secondary School.

Sessions of the conference centered around junior and senior high school science programs, class and laboratory methods, school-community programs, and the qualifications and training of teachers of able and motivated students in science. Emphasis was given to classroom aspects of teaching science to talented high school youth.

Plans for the conference were developed by Charles E. Bish, Director of NEA's project on the Academically Talented Student, Dr. Donaldson, and Robert H. Carleton and Margaret J. McKibben of NSTA headquarters.

On-the-Job Research Grants

At a meeting of the FSAF committee on research grants for secondary school science teachers on October 31-November 1, financial aid to teachers for on-the-job research was approved for the following applicants:

Mr. Richard Salinger, Wilton High School, Wilton, Connecticut; Mrs. Ethelreda Ross Laughlin, Cleveland Heights High School, Cleveland Heights, Ohio; Mrs. Mary Valasky, Senior High School, Fort Lauderdale, Florida.

These financial grants are provided to assist teachers in carrying on scientific research in after-school courses, and also during the summer months. Practically all of the research projects involve the participation of some of the more able science students that are enrolled in the classes of these teachers. The funds are for use primarily in defraying expenses of materials, equipment, and essential travel related to the research project.

Currently these grants are not sufficient to cover salaries either of the teacher or the students, but it is hoped future grants may include such provisions as the FSAF program of research grants for secondary school science teachers progresses.

FELLOWSHIPS FOR SECONDARY SCHOOL TEACHERS

The **National Science Foundation** announced a new program of Summer Fellowships for Secondary School Teachers to enable candidates to conduct graduate study and research in the biological, physical, and mathematical sciences. The Fellows may pursue individually planned study programs at institutions of their choice.

Approximately 750 awards are available. Stipends will be at the rate of $75 for each week of tenure, with allowances for travel, dependency, tuition and fees. Normal tenure will be two full summers of study, or three full summers if needed, and as short as one summer session.

DO NOT APPLY TO THE NATIONAL SCIENCE FOUNDATION. For applications, write to The Teacher Program, American Association for the Advancement of Science, 1515 Massachusetts, Ave., Washington 5, D. C. Completed data must be in by January 19, 1959, and selection of Fellows will be announced March 25, 1959.

During 1959, the **General Electric Educational and Charitable Fund** will again sponsor Fellowships for 150 junior and senior high school chemistry and physics teachers. The courses are for six weeks, from June to August, and offer graduate credit. Tuition, board, lodging, and travel will be provided. Please write R. D. Stanton, Planner-School Services, Educational Relations, General Electric Company, 570 Lexington Ave., New York 22, for names of schools that are accepting applications from your state. Applications must be completed by late February.

SCIENCE TEACHING MATERIALS

Prepared by NSTA Teaching Materials Review Committee
Dr. Robert A. Bullington, *Chairman*, DeKalb, Illinois

BOOK BRIEFS

BIOLOGY, REGENTS COURSE. Maurice Basseches, Editor. 205p. 80¢. The Board of Education of the City of New York, Publication Sales Office, 110 Livingston Street, Brooklyn 1, N. Y. 1958.

This course of study emphasizes using the methods of science in solving problems. In part a book on methods, it discusses teaching procedures such as individual laboratory method, the demonstration, the field trip, evaluation, and providing for the talented student. Each of the nine units has a topic outline with suggested activities, references, and audiovisual materials.

FREE AND INEXPENSIVE LEARNING MATERIALS. Division of Surveys and Field Services. 256p. $1.50. George Peabody College for Teachers, Nashville, Tenn. 1959.

This publication is the ninth in a series. It is designed to help the teacher, pupil, and librarian to collect current sources of information. With few exceptions, nothing is listed which costs more than 50 cents. Each title is annotated and is followed by the complete address of the distributor. Each pamphlet, poster, picture, chart, and map was selected after it was examined and evaluated. The entries are classified under 300 common subject headings with extensive cross references.

CREATIVE SCIENCE SERIES. Etta Schneider Ress, Editor, in cooperation with the American Museum of Natural History, New York. $29.74 per set. Creative Educational Society, Inc., Mankato, Minn. 1957.

Suitable for upper elementary and junior high grades as classroom instructional aids or text-supporting materials. The four volumes include: 1. The Way of the Weather. Jerome Spar. 224p. Covers the atmosphere, seasons, winds, weather of the world, forecasting, and tools for determining weather. 2. Atoms, Energy, and Machines. Jack McCormick. 224p. Covers matter, energy, measurement, simple machines, the role of physics and chemistry in everyday life, and the power of the atom. 3. Planets, Stars and Space. Joseph Miles Chamberlain and Thomas D. Nicholson. 223p. Covers the earth, moon and sun, solar system, galaxies, constellations, and tools of the astronomer. 4. The Earth's Story. Gerald Ames and Rose Wyler. 222p. Covers the ever changing land building and rebuilding of the earth's crust, the parade of life, raw materials of the earth, and suggestions for obtaining aids from various sources for material about the earth's history.

PHYSICS CALCULATIONS. Russell H. Johnson. 154p. 65¢. College Entrance Book Company, New York 11, N.Y. 1957.

The book contains a good collection of problems in physics covering mechanics, heat, sound, light and electricity. Each group of problems is preceeded by theory and example; a good source of interesting problems for teachers and high school students who wish to go beyond those in the ordinary text.

ELECTROSTATICS. Alexander Schure. 64p. $1.35. John F. Rider Publishers, Inc., 116 West 14th Street, New York 11, N. Y. 1958.

The concepts of electrostatic principles play a very important role in the understanding of electrodynamical problems. This book is a good attempt to clarify those fundamental principles. Coulomb's law and Gauss's law, which are basic to the understanding of electrostatics, have been introduced and applied to some problems in a clear and simple manner. The CGS and MKS systems, which are very often confusing to students, have been explained clearly. The simultaneous use of both the systems is good.

ATOMIC RADIATION. 110p. $1.60. RCA Service Company, Camden 8, N. J. 1957.

This publication presents the theory, biological hazards, safety measures and treatment of injury associated with atomic radiation.

The material presented is up-to-date, concise, readable and well illustrated. A handy reference for all teachers of natural sciences and interested students.

PROFESSIONAL READING

"Promising Experiments in Education." By Paul Woodring, *The High School Journal,* 62:2-16. October 1958. Discusses leadership ideas, communication media, and proposals in team-teaching, television use, curriculum changes, and teacher training.

"Genetic and Somatic Effects of Carbon-14." By Linus Pauling. *Science,* 128:1183-6. November 14, 1958. Calculations are made of the predicted genetic and somatic effects of the carbon-14 produced by the testing of nuclear weapons.

"Modifying Weather on a Large Scale." By H. Wexler. *Science,* 128:1059-63. October 31, 1958. Current proposals to modify the weather are discussed. Predictions are also given of what the meteorological consequences might be in dealing with comprehensive weather phenomena.

Standards for Materials and Equipment for the Improvement of Instruction in Science, Mathematics, and Modern Foreign Languages. Report of a conference sponsored by the Council of Chief State School Officers, Washington, D. C. 42p. 1958. Copies available only through State Departments of Education.

"Science Teaching Improvement Program." By J. R. Mayor. *Science,* 128:1262-5. November 21, 1958. A summary report on 3 years of activity of the STIP of the American Association for the Advancement of Science under a grant from the Carnegie Corporation.

The Indianapolis Science Education Story. By Paul E. Johnson and Newton G. Sprague. 20p. Free. 1957. Thomas Alva Edison Foundation, Inc., 8 W. 40th Street, New York 18, N. Y. A description of improvement in science teaching and the upgrading of staff and equipment.

The Detroit Science Education Story. By Samuel M. Brownell. 20p. Free. 1957. Thomas Alva Edison Foundation, Inc. 8 W. 40th Street, New York 18, N. Y. An address covering the general aspects of science education and the specifics of the Detroit program.

The Oklahoma Science Education Story. By James G. Harlow and Lyle M. Spencer. 20p. Free. 1957. Thomas Alva Edison Foundation, Inc., 8 W. 40th Street, New York 18, N. Y. Addresses concerning science education in Oklahoma, especially the program for identification of talented youth.

"The Weather." By Grace E. Koerner. *The Grade Teacher,* Darien, Conn., 76:44. December 1958. How weather is forecast.

"The Air Envelope." By Franklyn M. Branley. *The Grade Teacher,* Darien, Conn., 76:51. December 1958. A description of the "layers" of the atmosphere. List of activities. Bibliography.

"Unintelligence Tests." By Thomas E. Allen. *The Clearing House,* Fairleigh Dickinson University, Teaneck, N. J., 33:131-135. November 1958. One of the major shortcomings of intelligence tests is that they fail to measure what they purport to measure.

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Index—February through December 1958

The annual index is designed to be functional and space-conserving. Listed alphabetically by authors, the individual articles are coded according to topic category in bold-face figures. The key to the codings appears at the bottom of each page. TST's editors will welcome reader reaction to this index format.

(1) Conservation (2) Education of Science Teachers (3) Elementary School Science (4) Experiments, Demonstrations, and Pupil Projects and Activities (5) History, Philosophy, Goals, and Objectives (6) Information for Science Teachers (7) Instructional Suggestions, Methods, and Materials (8) Investigations, Research, and Fact-Finding Studies (9) Science Clubs, Fairs, and Exhibits; Science Talent Searches (10) Science Course Content, Organization, and Curriculum

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NSTA Activities

FSA Activities

HECTOR SAYS:

The Executive Secretary and staff told me they had a new publication ready to announce. In getting ready for this issue, I just put everything here in the bag. I hope I can find it.

AUDIO-VISUAL AIDS

ANIMALS MOVE IN MANY WAYS. Designed for use in science and language arts at the kindergarten-primary level, but of considerable interest to all ages. Illustrates the method of locomotion of children, dogs, horses, antelopes, wallabees, katydid, inchworm, millipede, snail, fish, ray, pelican, hummingbird, and dragon fly. II min. Color $100, B&W $50. 1957. Film Associates of California, 10521 Santa Monica Boulevard, Los Angeles 25, Calif.

COMBUSTION. Contains many demonstrations and experiments that cannot be done practically in the school laboratory. Shows the requirements for combustion, five factors controlling the rate, nature of spontaneous ignition, combustion characteristics, extent, and results of combustion. 15 min. Sound. Color $130. 1958. Produced by Manufacturing Chemists' Association, Inc. Available for loan from John Sutherland Productions, Inc., 201 N. Occidental Blvd., Los Angeles 26, Calif.

CHLORINE—A REPRESENTATIVE HALOGEN. This film thoroughly covers a typical textbook section on chlorine and shows much that the teacher is not likely to be able to demonstrate to high school or college classes in general chemistry. Film includes the nature of chlorine as an element, ion, and in compounds. Physical and chemical properties are shown and the laboratory production of chlorine is demonstrated. The reel closes with the uses of chlorine in the chemical industries. 15 min. Sound. Color $130. 1958. Produced by Manufacturing Chemists' Association, Inc. Available for loan from John Sutherland Productions, Inc., 201 N. Occidental Blvd., Los Angeles 26, Calif.

TREASURES OF THE EARTH. Designed to supplement the text series Heath Elementary Science for the middle grades, but useful through high school. Clear animation shows some of the ways minerals and metals have been deposited in the earth and concentrated in veins. Describes formation of oil and coal deposits. 11 min. Color $100, B&W $50. 1958. Churchill-Wexler Film Productions, 801 N. Seward St., Los Angeles 38, Calif.

MICROORGANISMS: HARMFUL ACTIVITIES. Content varied, but includes Koch's postulates and various body defenses against disease. Covers the protection of food and drink against the effect of harmful organisms. Of value for high school or college biology. 15 min. Color $150, B&W $75. 1958. Audio-Visual Center, Indiana University, Bloomington, Ind.

MOVING THINGS ON LAND. This film designed for use in the middle grades is correlated with the Heath Elementary Science texts. It is an amusing and enlightening story of the problems of two boys in moving a heavy box. The importance of friction in daily life as well as methods of overcoming it are clearly shown. 11 min. Color $100, B&W $50. 1958. Churchill-Wexler Film Productions, 801 N. Seward St., Los Angeles 38, Calif.

THE STORY OF ANYBURG, U.S.A. A mythical town overrun with a very real traffic fatality record and the method used to overcome the problem is the basis for Walt Disney's newest humorous and thought-provoking film. This completes a trilogy of safety films, the others being Motor Mania and How to Have an Accident in the Home. 9 min. Color. Long-term lease fee of $125. 1958. Educational Film Division, Walt Disney Productions, Burbank, Calif.

Well, here it is, *sans* color, *sans* stitching, and *sans* cover—but THESE ARE OUR SENTIMENTS.

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